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AIRPORTS - THE MILITARY POSITION OF AVIATION

by
V. K. Buzunov

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What the Book is About

(In lieu of an Introduction)

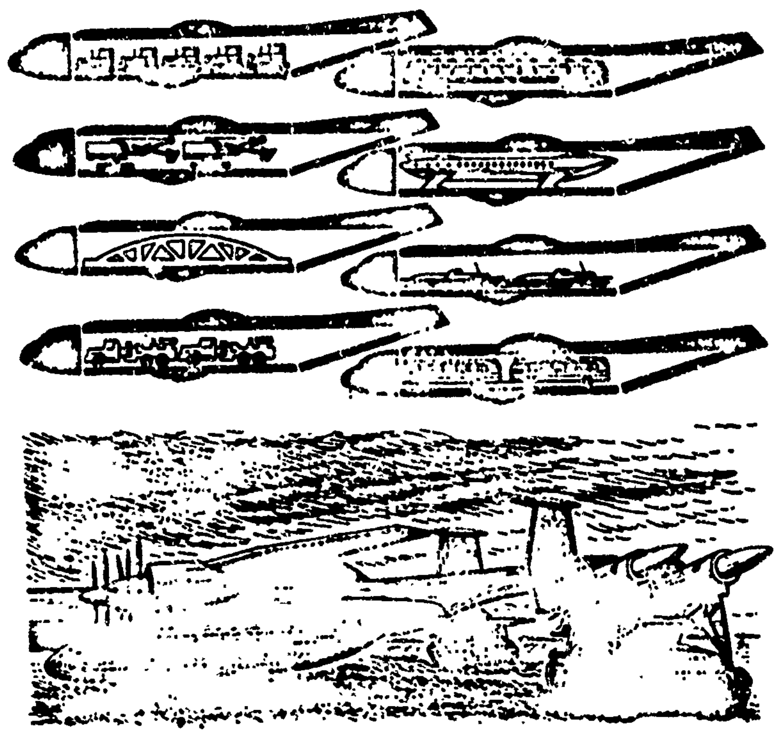
In the summer of 1965 the traditional 26th International Review - Salon of aeronautics and space was held at the LeBourget Airfield located in the Environs of Paris. Airplanes, helicopters and missiles - more than 350 exhibits from many countries of the world - were spread out over the concrete runways of the airfield. In the unanimous opinion of the French press, the Soviet aircraft IL-62, Tu-134, An-12, An-24 and the helicopter V-10 were at the center of attention of visitors to the exhibition.

The fifth day of operation of the Salon was marked by a sensation. The gigantic Soviet transport plane An-22 "Antaeus" arrived at the exhibition.

The pages of the newspapers flashed headlines: "An Enormity from Fantastic", "Flying Steamship", "Elephant over Paris". The influx of airplanes to the LeBourget Airfield increased: instead of 200-250 planes there were now up to 800 planes arriving per day. As many as 2,000 visitors per hour passed through the cargo compartment of "Antaeus", which had been set up as exhibit No. 1. The visitors to the exhibition were struck by the size of the airplane and its flying specifications. This is what caused the surprise: the dimensions of the cargo compartment - 33 × 4.4 × 4.4 meters; maximum payload - 80 tons of cargo or 720 passengers; flying weight - up to 250 tons; maximum speed in horizontal flight - 740 kilometers per hour; range with maximum payload - 5,000 kilometers and with a load of 45 tons - 11,000 kilometers; the plane has four turboprop engines, each of which delivers 15,000 hp.

"Russians win the battle of Bourget", wrote one of the Paris newspapers.

At the time of the aviation celebration in the summer of 1967, the line transport aircraft An-22 took part in an airborne assault landing on the Domodedovo Airfield. It transported self-propelled missile complexes.



What "Antaeus" Can Do.

The designers gave the An-22 the name of "Antaeus", one of the heroes of Greek mythology. According to ancient legend, Antaeus was the son of Poseidon, God of the Sea, and Ge, Goddess of the Earth. He accomplished many exploits and for a long time no one could defeat him. Each time he got into trouble in combat with an adversary he touched the earth - his mother - and he received new strength and defeated his adversary. The strength of this mythological hero was to be found in his unbreakable bond with the earth. The figure of Antaeus embodies all of aviation from the moment of its inception right up to our own day better than anything else could.

Airplanes are built on the earth. They leave the earth to fly into

the air. And no matter how long the airplane remains in the air, it must return to the earth, which provides the plane and its crew with strength for another flight - victory over the adversary. When this strength is consumed, the aircraft - just as the mythological Antaeus - must touch the earth again in order to acquire new strength.

However, the earth, which gives strength to the airplanes, is not a mythological goddess; it is a human creation. But this "human earth" cannot receive airplanes and provide them with all the necessities for flight and combat operations at all times and in all places. In contrast to the mythological Antaeus, airplanes do not acquire new strength any time they touch the ground, but only at certain areas which are especially prepared by people. These areas are called airfields. Airfields for military aviation are often called ground combat positions. And it is really so. Military aircraft take off from airfields in order to carry out combat operations. But this does not exhaust the role of airfields as the ground combat position of military aviation. The plane and its crew have need of many different material things in order to fly and to carry out combat operations: fuel, ammunition, oxygen, compressed air, etc. The airplane should be ready to fly. The crew of the plane is in need of relaxation, food, and medical checkups. Before flying in a contemporary high-speed, high-altitude airplane, the pilot dons a special suit and parachute. All this and more, too, must be provided by the airfield.

Aviation in general and military aviation in particular is a child of the 20th Century. The outstanding role played by Russian scholars and designers in the development of aviation science and engineering must be noted. The names of A. F. Mozhayskiy, K. E. Tsiolkovskiy, D. I. Mendelyev, N. Ye. Zhukovskiy, Ya. M. Gakkel and many others are inscribed in the history of aviation in golden letters. The world's first airplane was constructed by A. F. Mozhayskiy as far back as 1882. The Soviet Union is now in the vanguard of world-wide aviation progress.

At the beginning of the development of aviation, airplanes required little flight service. A few score liters of gasoline and a few liters of castor oil for the motor, a special suit for the pilot, who at that time was located in the completely open cockpit of the airplane generally on the wing in front of the motor. The airplanes, especially military planes, often broke down, and the matter of constant repairs was just about the primary difficulty in support of normal operation.

In our day, the situation has changed drastically. The speeds and altitudes of flight have become enormous. The requirements for ground support of aircraft are many, varied and stringent.

Ground-based support to aviation has developed and become more sophisticated along with the development and growing sophistication of aeronautical engineering and its ever widening application to military purposes. The first aviation units created at the very beginning of military application of aviation had a small number of airplanes under arms. These units also acquired manpower and resources which provided for ground-based support in its entirety, including also the preparation of airfields. Gradually as the number of airplanes increased, the designs became more complicated, the flying weights increased and better armament was prefected, and also in connection with the development of tactics and methods of combat application of aviation during wartime, the functions of ground-based support became more clearly defined and later ground-based support became an independent field of aviation activity. The experience of the preceding world wars, especially the Second World War, served as the basis for the creation of a system of ground-based support to military aviation which today includes distinct and independent departments and services each of which accomplishes certain tasks which together make up the complex of tasks of ground-based support.

It must be said that the division of functions of ground-based support among distinct and frequently organizationally independent services is characteristic for contemporary military aviation of the vast majority of developed countries of the world. Thus, for example, the tasks of direct technical servicing and repair of aviation equipment is accomplished by an engineering aviation service which organizes and provides engineering-aviation support; the tasks of radio-technical support and communcations are accomplished by the communications and radio-technical support service. The majority of other tasks of ground-based support to military aviation in those countries where this aviation has become a special branch of the Armed Forces is accomplished by manpower and resources which in the aggregate make up the aviation rear.

The rear is often associated with a military train which is located far behind the troops carrying on combat operations and has mobile field kitchens, cooks and ration dumps. Of course even in our own day mobile kitchens and ration dumps and personnel carrying out this work are found in the rear. However, the provision of food, however important it is, is not the most important task of the rear. Besides this the rear accomplishes a whole complex of complicated jobs in supporting the troops with everything necessary for combat and life. The aviation rear itself prepares that "earth" which receives airplanes and their crews and supports them with everything necessary for flight and combat operations.

What then are the basic tasks of the aviation rear? It prepares

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the ground-based material base from which aviation is able to carry out combat operations, and in times of peace, can carry out combat preparations and maintain a high state of combat readiness. The foundation of this base is the airfield on which are located aviation units or elements.

Aviation is the most maneuverable branch of the Armed Forces. Aviation units equipped with contemporary aircraft are able to fly quickly from one airport to another and concentrate forces there where the situation requires it. However, in order for aircraft carrying out a maneuver to be able to land in the required area it is necessary that an airfield be prepared and to have support manpower and resources deployed there, i.e., manpower and resources of the rear. During the Great Fatherland War [Tr. Note: World War Two] there was a half-jesting and half-serious expression among our aviators: "Aviation fights with the rear services forward". This very neatly defined the peculiarity in the activity of the aviation rear -- its manpower and facilities had to appear in new operations-base areas earlier than the airplanes flew there. This peculiarity in the activity of the aviation rear also conditions the basic peculiarity of its organizational structure and equipment supply system. In order to guarantee a high degree of mobility, or as they say maneuverability, to the aviation rear, it was organizationally detached from the aviation units. A good equipment supply system of the aviation rear permits it to be transferred quickly to new operation-base regions of aviation units along with those necessary material and equipment resources supporting combat operations of aviation, i.e., this also improves its maneuverability.

The tasks of the aviation rear are complicated, varied, and highly responsible. We will only point out a few of the main ones which determine its organizational structure and make up.

The most important task of the aviation rear is the construction (preparation) of airfields. It has already been mentioned above that aviation units and elements land their aircraft and base them on airfields which have been constructed earlier. For that reason the aviation rear has in it special forces and resources with the help of which the search for tracts of land suitable for the construction of airfields is carried out, in addition to the designing and construction of airfields. These are so-called engineer-airfield (airfield-construction) units and elements equipped with the necessary engineering equipment and having appropriate specialists to carry out all the work for which a need might arise in the construction of the airfield.

The next task of the aviation rear is the airfield-technical support to aviation, i.e., flight service at the airfield. This includes:

maintaining the airfield at a constant effective readiness, supporting the preparation of aircraft for flight with all the necessary material and technical resources, providing food for the aircraft crews at the airfield, their medical services and a number of other measures. The basic aim of airfield-technical support is the creation of conditions necessary to sustain flights of aviation units (training units in peacetime, combat units when carrying out combat operations). In order to provide airfield-technical support, special aviation-technical units and elements are present in the organization of the aviation rear.

Tasks of the aviation rear such as material and medical support should also be mentioned.

Material support consists in supplying the aviation units with material resources necessary to conduct combat operations or to carry out military training and also in the provision of rations and personal services for the personnel of the units, including pay and allowances.

Medical support embraces special medical measures to sustain the health and combat effectiveness of the personnel, to prevent disease, to heal the sick and the wounded, to check on the rations and personal conditions of the personnel, etc.

Material and medical support at the airfield occurs primarily with the help of the aviation-technical (support) units and elements. But to accomplish these tasks, other units and services of the aviation rear are brought in. These are transportation units which transport material resources to the airfields, medical services, laboratories, headquarters elements, supply depots, etc.

They say that any chain is no stronger than its weakest link. The links in the chain which make up the activity of the aviation rear are its tasks. And in order to successfully cope with support to aviation, the rear should guarantee the equal strength of all of its links. This book which is intended for the reader who is interested in military aviation discusses one link which characterizes the activity of the aviation rear - the airfield-technical support to aviation.

The Airfield - "The Earth of Airplanes"

In our day of rapid progress of aviation and its wide application in various branches of the domestic economy, it is hard to find a person who does not have a general idea of what an airport is or at least who doesn't know that an airport is a place where airplanes are located and where they takeoff and land. Every year the airplanes of our Aeroflot transport millions of passengers, each of whom has been at an airport even if only twice - at the beginning and ending of a flight. Millions of viewers each year see domestic and foreign films about civil and military pilots, their job, boldness and courage. In the films there are, of course, shots showing the airport.

Thus, as a rule, people have an idea of what an airport is. However, this is a general idea which more often than not amounts to the knowledge that an airport has an air terminal and a concrete runway. Some people may also notice the presence of a dispatcher point from where flight control is exercised.

This book will enable the reader to acquire a more complete notion of the contemporary military airfield, its basic elements and equipment, and to become acquainted with the classifications of military airfields. And here the reader will also find short summaries concerning airfields for seaplanes, helicopters and deck aircraft.

What Is an Airfield?

An airfield or airport is a complex of specially prepared and equipped parcels of land and buildings which support takeoff, landing, parking and servicing of aircraft.

The contemporary military airfield as a rule comprises three elements: landing field, service and equipment area, and living area.

The basic element of the airport is the landing field, which is an area designated and equipped for takeoff, landing, taxiing (towing) and parking of aircraft.

The construction of airfields having certain requirements was begun during the First World War. In accordance with the then current requirement, landing fields were constructed in the form of a circle or a square, or nearly so. This form of airfield permitted take-off and landing in any direction depending on the direction of the wind because in those years airplanes could take-off and land only straight against the wind. Take-off and landing with tail winds or side winds was at first completely

impossible. While this was done later, it was only accomplished at great risk.

The landing field of modern airports is laid out in the form of a rectangle, the longest sides of which are laid out in the direction of the wind prevailing in a given area. Meteorological observations are used to discover this direction, as a result of which a so-called "wind rose" is constructed, i.e., a diagram which shows in percent the repetition of wind direction for the period of observation. The longer the period of observation, the more accurately the direction of the prevailing wind in the area of the airfield can be determined. At modern airfields, the whole landing field is not used for takeoff and landing, rather only a part of it - the runway (RW). [Tr. Note: letnaya polosa]. The majority of modern, permanent airports and all temporary military airfields have one runway. The runway is the basic part of the landing field of the airport; it consists of the working area and lateral and terminal safety zones.

The working area of the runway is intended for the starting run and liftoff of aircraft during takeoff, landing, and stopping room after touch down. In order to assure the opportunity for flying at any time of the year, a takeoff and landing strip (TLS) [Tr. Note: vzletno-posadozhnaya polosa] with a synthetic covering maybe constructed within the limits of the working area (at its edge).

Safety zones are located at the sides and ends of the runway. The lateral safety zones are provided to assure safety of aircraft in case of any deviation to the side beyond the limits of the working area during takeoff or landing. The width of each such zone is 50-100 meters. The end zones are intended to assure the safety of aircraft in case it should roll pass the limits of the working area during takeoff or landing. The width of each such zone is 200-400 meters.

Taxi strips, parking places for aircraft, and pre-takeoff areas are also parts of the landing field.

Taxi strips (TS) [Tr. Note: rulezhnye dorzhki] are parts of the landing field designed for taxiing (i.e., for independent movement) or the towing of aircraft by means of tractors to the starting point for takeoff and to the parking places after landing. Depending upon the location on the landing field, the taxi strips are subdivided into main lines located parallel to the runway and connecting each of its ends; connecting lines which join the stopping places of the aircraft on the runway after landing with the main lines of the taxi strips; auxiliary lines joining the main lines of the taxi strip with the aircraft parking

places and individual buildings of the service and equipment zone of the airport. Taxi strips frequently have synthetic covering similar to the covering of the takeoff and landing strip.

The aircraft parking places (PP) [Tr. Note: mesta stoyanok] are specially constructed and equipped sectors of the landing field designed for parking and servicing of aircraft. Parking places may be individual, i.e., separate for each airplane or collectively intended for a group of airplanes. Parking places may be completely covered with synthetic material or only partially so under the wheels of the aircraft landing gear (screens). In addition, parking places may have mooring devices, recoil (deflecting) screens for diverting gas jets from the airplanes engines when checking them out, and also other equipment.

At many military airfields, parking places may have covers of various construction for protecting the aircraft located there from shock waves and fragments of ammunition in case of an air raid on the airfield or shelling by ground forces of the enemy.

Pre-takeoff areas are sectors of the landing field of the airport which are located at the ends of the runway and intended for free-takeoff servicing of aircraft and also for stationing duty aircraft of aviation elements. These areas have synthetic covering similar to the takeoff and landing strip.

Military airfields are classified according to different characteristics. One of the most important characteristics is the size of the runway. Depending upon the size of the runway, airfields in many countries are subdivided into first, second and third class airfie... superclass aerodromes and landing fields[1].

First class airfields are designed for basing aircraft of long-range (strategic) aviation. The length of the runway of such airfields is not less than 3,300 meters. If there is TLS with a synthetic surface at a first class airport, it is usually 2,500 × 80 meters in size.

Second class airports are designed for basing airplanes of front (tactical) aviation, and also air defense fighters. The length of the runway of these airfields is 2,200-2,800 meters. TLS with synthetic surface has the dimensions 1,800-2,000 × 50 meters.

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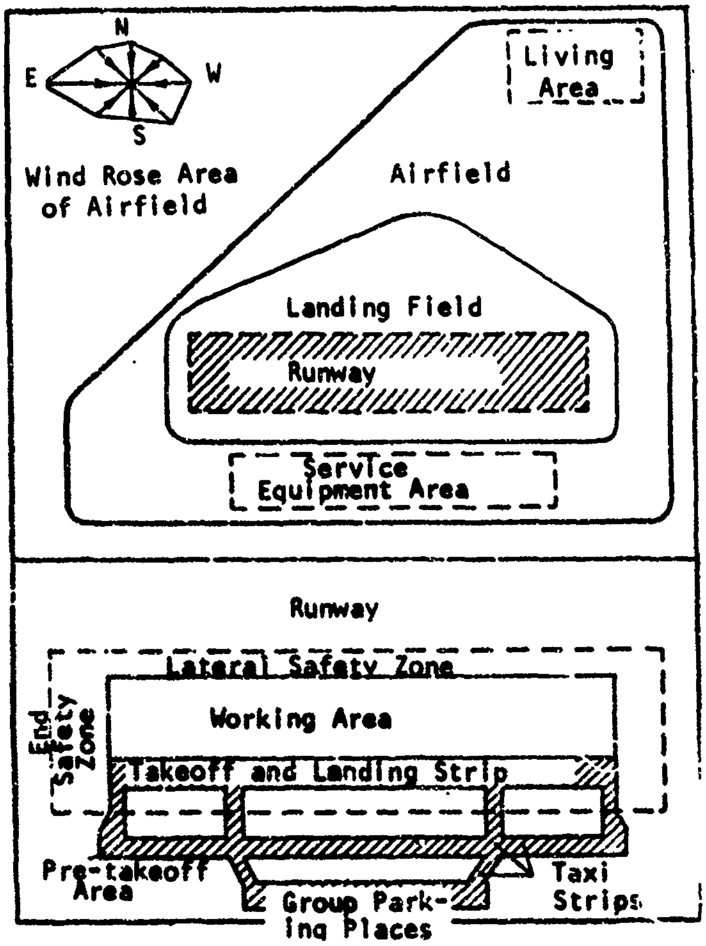
[1]In some countries, for example in the United States, instead of dividing into classes, they are divided into airfields for strategic, tactical and military transport aviation.



Basic Elements of the Airfield and Parts of the Landing Field.

Third class airports are designed for basing aircraft of military transport and auxiliary aviation. As a rule these are propeller-driven or turboprop aircraft. The length of the runway of the third class airport is 1,200-1,600 meters, and the TLS with synthetic surface is 1,000-1,200 × 50 meters.

Superclass airfields (aviation bases) are designed for basing aviation, the testing of aircraft and for other special purposes. As a rule, such airfields have several landing fields and TLS with synthetic surface, the dimensions of which exceed the dimensions of the runway and TLS of first class airfields.

Landing areas are designed for short-term basing of light aircraft and helicopters. They have limited dimensions and are not equipped with any kind of special facilities.

The second most important element of the airfield is the service and equipment zone. In this zone of the airfield are found facilities, buildings and equipment designed for flight control, support for takeoff and landing of aircraft under difficult weather conditions and at night, engineering service and aircraft repair, storage for reserves of material resources (fuel, ammunition, etc.), quartering of staffs, facilities for ground-based support of flights and facilities for effective maintenance of the landing field of the airfield.

The servicing and equipment zone of the airfield is usually adjacent to the landing field.

The third element of the airfield is the living area. Buildings and installations designed for quartering the personnel of the units deployed at the airfield and for their cultural and communal-routine services are located here. In the majority of cases this zone of the airfield is found several kilometers distance from the landing field and the service and equipment zone.

Airfields are also classified according to the degree to which they are equipped with all these basic elements. By this criterion they are subdivided into permanent and temporary (field)[1].

Permanent airfields have capital installations and stationary equipment. They are designed for long-term basing of aviation units and elements primarily under peacetime conditions.

Temporary (field) airfields have temporary installations and mobile equipment and are designed for short-term basing of aviation primarily during the course of combat operations.

How does a modern plane takeoff and land? If executed normally, the take-off consists of three stages: ground acceleration run, airborne acceleration and climbing to gain altitude. The initial acceleration takes place on the ground, more accurately along the surface of the runway or TLS, until obtaining the speed necessary for lift-off, at which the

[1]Henceforth in the interest of brevity only the term "temporary airfields" is used. This is equivalent to the term "field airfields" and also to the term used in some countries "forward airfields of tactical aviation".

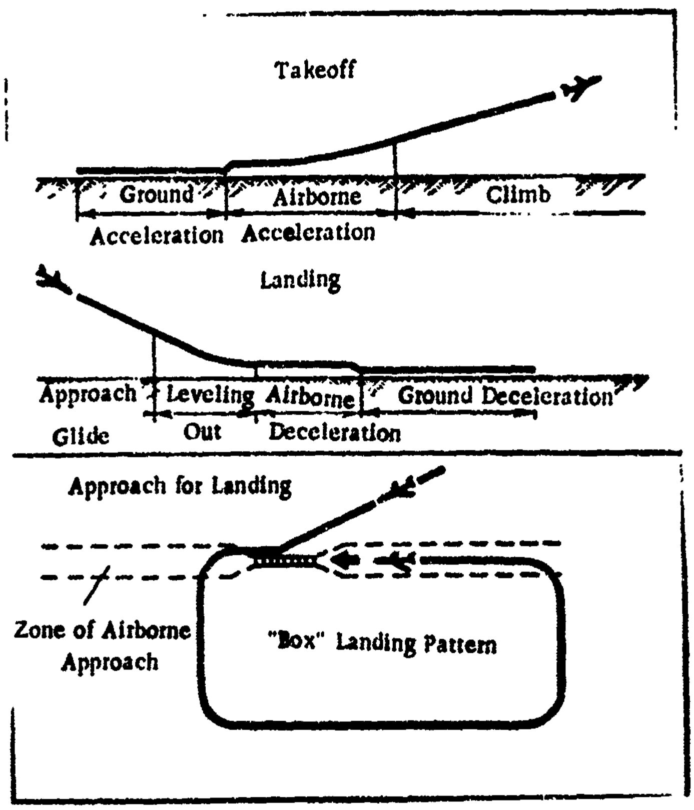
lifting force equals the weight of the moving plane. At the end of the acceleration run on the ground, the plane lifts off the ground and during the stage of airborne acceleration it accelerates to the speed necessary to gain altitude. This later acceleration takes place at a very low altitude (close to the ground) with gradual but slight increase in altitude. Finally, the aircraft goes through the climbing stage which culminates at an altitude of about 25 meters. Having accomplished all three stages of take-off, the pilot acts in accordance with the flight plan. Before landing, as a rule, the pilot goes through a maneuver which is generally called in aviation a box pattern. This is flying over the airfield, or more accurately, over the airfield area along a nearly rectangular flight path which results in the pilot turning the plane on to the landing course. This is how the landing approach is done. The landing itself is done in four stages: approach glide, leveling out, airborne deceleration, and ground deceleration. The approach glide with decreasing altitude begins with the approach of the airplane to the airfield at an altitude of approximately 25 meters. Then in the leveling off stage, the plane is brought into a horizontal path close to the ground and at the airborne deceleration stage flying close to the ground the speed of the airplane is reduced to landing speed. At the end of the airborne deceleration, the plane touches down (on the surface of the runway or TLS) and completes the landing by decelerating along the ground. Consequently, in order to take off and land, some so-called airfield-contiguous territory is required.

Airfield-contiguous territory is a place abutting the airfield, in the airspace above which the aircraft can gain altitude when taking off, go into an approach glide when landing, and maneuver in the air during takeoff and landing. The tracts of air-space over the adjacent territory contiguous to the ends of the runway of the airfield and laid out in the direction of take-off and landing are called air approach areas.

Air approach areas must be of sufficient expanse, and most important, must not have any vertical obstacles which exceed the norms adopted in relation to the class of airfield and in relation to whether the airfield is permanent or temporary. The necessity of having air approach areas for each airfield requires that neighboring airfields must be separated from one another by a considerable distance. The distance apart for modern military airfields must be several score kilometer. We note, however, that the last condition to a considerable extent reduces the possibility of constructing airfields in any given area even when there are a sufficient number of ground tracts suitable for construction.

It is well known that military aviation of the more advanced countries of the world includes land-based aircraft, helicopters, seaplanes

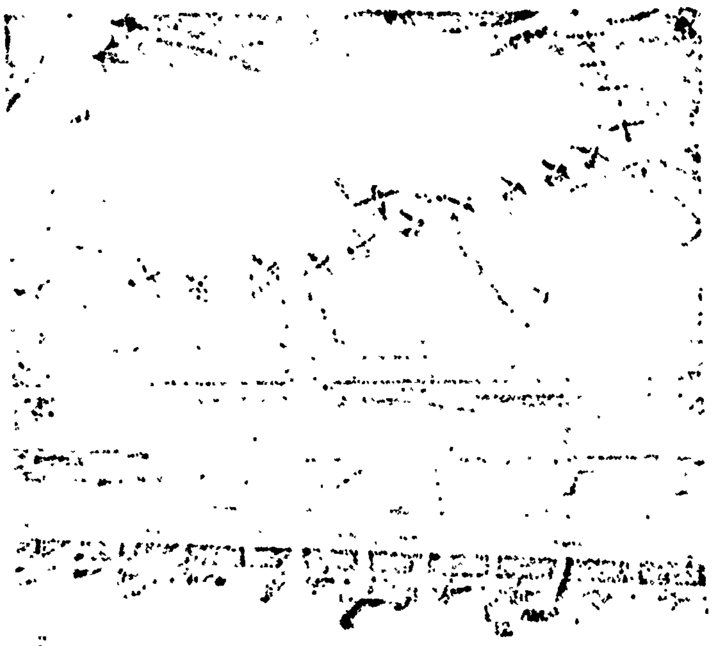
and deck aircraft (helicopters) operating from special ships - aircraft carriers. Airfields designed for basing all of these aircraft and helicopters, including "floating airfields" - aircraft carriers, have all of the elements mentioned above. However, even these elements at airfields designed for different airplanes or helicopters differ in facilities, shape and other characteristics.



Schematic of Take-off and Landing

Airfields for Aircraft

During the First World War, when extensive application of aviation for military purposes began and during the following years (up to the 1920's and 1930's) airfields were predominantly of the air earth type. Light aircraft of those years having landing gear with low-pressure tires (4-6 kg at 1 cm^2) operated successfully from bare-earth landing fields, which were circular or square in shape, and later rectangular, and finally merely strips (runways).



Taxi Strips and Parking Places on a Temporary World War II Military Field (1) and on a Modern Permanent American Airfield in South Vietnam (2).

The construction of bare-earth airfields at first was not very expensive. A level tract of required size was selected which was covered with good grass. Small uneven places were flattened and the shape of the relief was improved. As necessary, the grass on the landing field was mowed.

It must be said that even in those days the bare-earth airfields did not always guarantee uninterrupted flight. Later on as the weight and the takeoff and landing speeds of the aircraft steadily increased, as the air pressure in the tires increased and the wheel bearing surface was reduced, the deficiencies of bare flying fields became more and more evident. The hardness of the ground sharply decreased in rainy periods and without rain it was not sufficiently tough. With the intensive use, the grass cover of the bare runway is quickly destroyed, which also reduces the toughness of the earth and leads to the formation of dust in dry weather. Dust interferes with take-off and landing and promotes even faster wear of the essential assemblies and parts of the aircraft.

The question of the possibility of utilizing bare-earth airfields became especially critical in connection with the appearance of jet aircraft and the transition of practically all combat aviation to jets. The weight of modern aircraft exceeds by several score the weight of aircraft of analogous type in the period of the First World War and even in the case of fighter planes which are the lightest of all military aircraft the weight is 10 to 20 tons greater. Landing speeds of from 200 to 300 kilometers per hour are a normal occurrence in our day. The air pressure in pneumatic tires of modern aircraft comes to 10 to 12 kilograms/cm^2 and higher.

Consequently, the reader of aviation affairs is tempted to conclude that modern military aircraft cannot be based on bare-earth airfields. No, this is not so, although the limited possibility of using bare-earth aircraft is one of the most important reasons for the arising of the modern airfield problem. In addition, temporary airfields must have predominantly bare-earth runways.

There are two paths to assure the possibility of basing modern aircraft on bare-earth airfields. The first corresponds to a design adaptation for the aircraft themselves. The second concerns special measures on the airfields.

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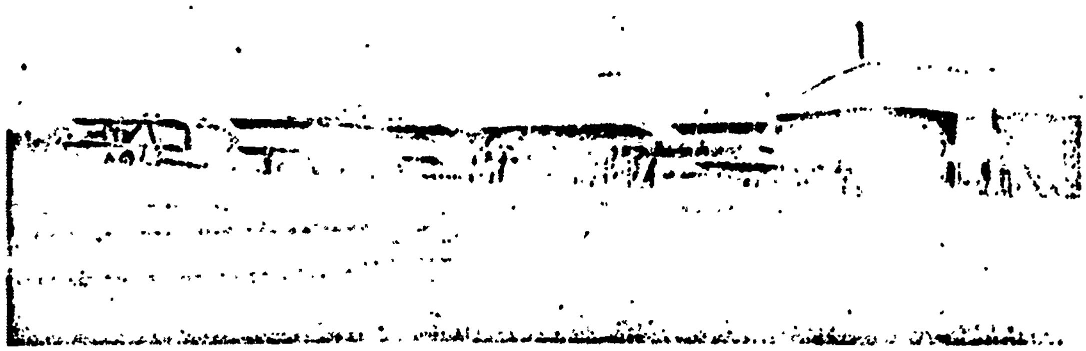


Wooden Runway on a Russian Military Airfield in the Period of the First World War.

The basic aim of all measures which are carried out on bare-earth runways to assure the possibility of their use by modern aircraft consists in increasing or maintaining a high degree of toughness of the ground. In those cases where it is impossible to achieve this, another

resort is the laying of synthetic surfaces on the takeoff and landing strip or on its individual sectors and also on the taxi strips and parking places.

Permanent and temporary airfields have a bare-earth portion of the landing field. But the permanent airfield always has a TLS with synthetic surface while the temporary airfield does not always have this. In addition, the synthetic surfaces on permanent and temporary airfields differ considerably in capital investment and in the materials used for their construction. In the Soviet Union we began in 1932 to use synthetic surfaces of concrete cement for TLS, runways and parking places on airfields of the military Air Force. This fact is interesting. The creator of the first airplane in the world, the talented Russian inventor, Naval Officer A. F. Mozhayskiy, built in 1882 at Tsarskoe Selo (now Krasnoe Selo) an inclined wooden platform which he used for launching his airplane. This was the first takeoff and landing strip in the world with a synthetic surface. Wooden synthetic surfaces were used in Russia for temporary airfields even in the period of the First World War.

In our day, the construction of every permanent military airfield begins with the installation of a synthetic surface on the TLS, taxi strips and parking places. The area of synthetic surface of the modern airfield comes to 250,000 square meters or more, or 20 to 25% of the total area of the landing field.

All-weather synthetic surfaces are characteristic for permanent airfields. The most widespread are concrete and reinforced concrete surfaces laid in the form of a monolith or laid in individual slabs of various shapes (square, hexagonal, rectangular) having a thickness of 10 to 30 cm and more. These surfaces are laid on specially prepared sand, sand-gravel or gravel base. The seams at the joints of the slabs are filled with special mastics or asphalt. Filling the surfaces in this way guarantees the possibility of uninterrupted and long-term use of the airfields by aircraft of practically any type. But they have a particular deficiency, which is that it consumes a great amount of labor and time in the construction of the airfield. For this reason synthetic surfaces of other types are used on airfields. These are types which can be laid considerably quicker than the all-weather surfaces and in the installation of which local materials can be used. Of course, such surfaces cannot be used for such an extended period of time and not all types of aircraft (branches of aviation) can fly from airfields having such surfaces. In contrast to the all-weather type, these surfaces are called strengthened and improved.

Strengthened surfaces are installed when there are local construction

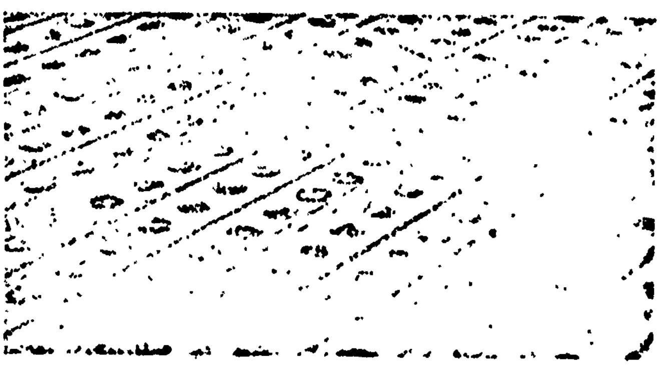
materials in the area of the airfield (gravel, slag, chips from mountain rocks or from bricks and concrete) which are mixed in a certain proportion with the earth of the landing fields and are pounded down with rollers. In this group we find earth-gravel, earth-rock chip, earth-slag and other similar surfaces.

Improved surfaces are made out of those materials used for strengthened surfaces but processing them with organic or mineral binding materials (asphalt, tar, cement, lime, etc.). In addition, earth, cement and black earth surfaces (using organic binding materials) are used which can also be considered under improved surfaces.

Although strengthened and improved surfaces are highly effective in use, much time, a large amount of construction materials, considerable manpower and resources are required for installation. In addition, the use of different type surfaces is limited by the climatic and seasonal conditions. Thus, for example, organic binding materials are not sufficiently effective in hot regions. For this reason prefabricated sectional synthetic surfaces find wide application for military airfields.

Prefabricated sectional surfaces are made of elements prepared in advance: metal slabs of various design, metal meshed and cellular sections, wooden planks or sections, concrete slabs and other elements.

A surface of prefabricated sectional elements can be laid directly on a leveled surface of the earth and also on a strengthened or improved surface for further reinforcement. After there is no longer a need for such a surface at an airfield, the surface may be collected, transported to a new place and again collected.



A Section of Prefabricated Sectional Surface of Metal Slabs.

During the Second World War in many countries the use of surfaces of steel slabs was fairly widespread. However, breaking up such surfaces and transporting these slabs for assembling the surfaces at a new place was not carried out. This is explained by the tremendous total weight of the slab complex for one airfield (several thousand tons) and the necessity to divert a large number of air transports to transport them. In the post-war years, the design of metal slabs has gradually improved. Slabs made of aluminum castings have been developed which has significantly reduced the weight of the complex. It is well known, for example, that the United States uses aluminum-slab surfaces widely for airfields in South Vietnam.

Surfaces of wood and concrete elements are, in fact, constructed and are not prefabricated sections, since it is impossible to collect them and transport them to new areas.

A first-class synthetic surface of the required dimension creates favorable conditions for flying at an airfield but nevertheless does not guarantee safety to the required degree. The most complicated and responsible stage of any flight (except the execution of a combat mission) is landing the aircraft on the airfield, especially landing at night, under difficult weather conditions, or with poor vision. For various reasons the pilot may land the aircraft not at the beginning of the runway but as they say "greased", and then the aircraft may roll beyond the confines of the runway onto the unprepared surface, which threatens an accident or even a catastrophe.

The takeoff of an aircraft is also difficult when the acceleration run takes place along a fairly narrow TLS having a synthetic surface. During the takeoff, if for any reason the acceleration run is broken off, the airplane also may roll on pass the confines of the prepared territory of the airfield.

All of this calls for the need to equip the landing field with means and devices to guarantee sufficient flight safety. Most widespread are radio and light devices and also braking devices (installations).

Devices which make up the radio and light equipment assure the possibility of landing on the airfield under difficult weather conditions and at night. Complimentary use of radio and light facilities permit such tasks to be accomplished such as the aircraft approach to the area of the airfield, landing approach and estimation for landing, and the execution of all the stages of landing and taxiing to the parking places.

The most complete radio and light signal equipment operates at

permanent airfields which are used primarily in peacetime and consequently do not require observing measures for radio and light-signal camouflage. Stationary and mobile equipments are used at permanent airfields. Camouflaged measures must be available at temporary airfields. For this reason, temporary airfields try to have a minimum number of radio and light-signal equipments, chiefly mobile and transportable.

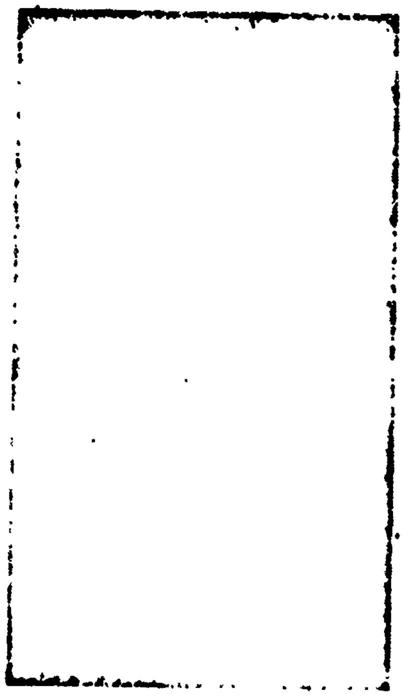
In different countries, there are various systems for assisting landing under difficult weather conditions and at night, but in principle the systems are based on practically one and the same devices. The chief ones among these are the following:

a) radio devices:

- radio course beacons -- to point out the landing course to the airplane crew;
- glide approach radio beacon -- to point out the flight path (glide path) for leveling out;
- radio marking points -- to designate locations of certain points in the area in relation to the beginning of the runway, and also for the approach of the aircraft to the area of the airfield;

b) light-signal devices:

- code light beacon -- for identification of the airfield by the airplane crew and for the initial visual orientation when calculating the landing;
- approach beacons (usually red) -- for the transition of the airplane crew from pilotage by navigation beacons to pilotage with visual orientation by light-signal devices;
- landing approach beacons (red) -- for pointing out the direction of the landing approach to the runway when the airplane levels off;
- landing lights (white) -- for defining the lateral borders of the runway;
- lights for orientation at the beginning and end of the runway and for permitting or denying landing;
- obstruction lights (usually red) -- for identifying obstacles at the airfield and in the area of the airfields within the confines of the zone of air approach which are dangerous because of height.



Modern Light-Signal Facilities
of the Permanent Airfield.

Light-signal facilities compliment the system of radio facilities and assist the descent of the aircraft from a particular altitude, the landing, the ground deceleration and taxiing by means of visual orientation of the crews by means of a system of lights of different colors located on the approach to the runway, on the runway itself, and on the taxi strip of the airfield.

The Lights (Bat) and the Electrofied (1) - The Simpiest Devices of the Light Facilities of the Airfield.

During the Second World War, the light equipment of military airfields in the majority of cases was composed of kerosene or electric lamps and the simplest electrofied landing marks, and pyrotechnical torches, griddles with cotton and oil, and campfires (chiefly on partisan airfields) were also used.

In order to prevent the breakup of aircraft rolling pass the limits of the runway, braking devices are widely used. They are of two types: airfield (emergency) braking facilities and areas of earth to slow down the aircraft (sand, gravel, etc.). Airfield braking facilities are installed while braking areas are constructed at the end safety areas. They have various designs to help stop the airplane, which is moving at high speed, along a tracted of 50-150 meters.

The increase in landing speed and the power of aircraft engines is the condition for further improvements in the special equipment of the landing field. Thus, for example, the marking (outlining) of the landing field and the runway of airports to assure visual orientation of the crews during the day has received wide application. The marking is carried out in the form of strips on the runway and different colored shields and figures on the approaches to the runway. More and more attention is being paid to fighting the noise of the aircraft engines. In order to minimize the unpleasant effect of this noise on people at the airfield, special mobile dampers are created. The effect of the powerful streams of gas from jet engines which is destructive to the airfield surfaces and dangerous for the service personnel is countered by means of special deflecting devices (shields).

At permanent airfields, the number of structures of the service and equipment zone is a maximum. With respect to capital investments, they are constructed in accordance with special requirements and they provide maximum convenience for working and for storage of material resources.

The reader who has been at an airfield of civil aviation (at an airport) has seen the installation called the command dispatcher point (CDP). Similar installations are also found at permanent military airfields. All the means for flight control are concentrated at the command dispatcher point. There is no stationary command dispatcher point at temporary military airfields. This role is carried out by transportable points for flight control, and they are mounted on trucks or tractors.

It is characteristic for temporary airfields to see stationary installations of the service and equipment zone replaced by mobile, prefabricated-removable and temporary installations. The available space is also utilized for housing the equipment at these airfields. Since

temporary airfields are used in wartime, the attempt is made to camouflage them and so the service facilities located there are dispersed and concealed. For that reason the service and equipment zone does not have any clear boundaries at a temporary airfield. The structures which make up this zone are spread out over a much larger territory than at the permanent airfield.

Elements in the Equipment of the Airfield:
1, transportable noise dampers; 2, emergency braking installations.

Many structures of the service and equipment zone which are found at permanent airfields practically do not exist at temporary fields. Thus, for example, technical facilities for ground service and temporary airfields are scattered about and are not found in installations and are located in natural concealment at the edge of forests, etc. Stores of aerial bombs and containers of aviation fuel may be located on the ground.

At temporary airfields wide use is made of earthen engineering installations or installations of metal, wood or other elements for concealing aircraft, technical facilities of ground service and material resources, and also for providing service space and control points. They are intended for short-term use and for that reason they do not provide sufficient convenience for people to work or good conditions for storage of materials. On the other hand, they guarantee a more or less effective

defense of control points, equipment and stores of material resources from damage or destruction during enemy action over the airfield or in its area.

There is a tendency for the living area at permanent airfields to be located at some distance from the flying and service and equipment zone in order to create agreeable conditions for living, relaxation and routine of the personnel. In addition, a separation of this zone from the landing field provides for relative safety of the personnel located there in case of enemy air strikes on the airfield. Of course, there is a real contradiction between the desire to provide for the safety of the personnel and the requirement for bringing the aircraft at the airfield into rapid combat readiness. The further from the landing field, and that means also from the aircraft, the flying and ground personnel are quartered, the more time is required to ready the aircraft for combat flight.

The living area at temporary airfields, just as in the case of the service and equipment area, is not firmly drawn. The quartering of personnel at such airfields to a greater extent than at permanent airfields is subject to the requirement to provide for a high degree of combat readiness. For this reason the living quarters at temporary airfields tend to be situated closer to the working sites of the personnel; in so doing, wherever possible the requirement to protect them in case of enemy air attack on the airfield is also satisfied. At the present time, particular attention is being paid to the defense of all airfield structures from nuclear weapons.

The presence of and the possibility of using area housing of local populated points has a great influence on the system of quartering personnel at the temporary airfield. In addition, in those cases where local facilities are not satisfactory, the construction of temporary living quarters for housing personnel is envisaged (dugouts, prefabricated houses, etc.), and also the use of tents, inflatable and prefabricated sectional installations.

It must be noted, and what has been said about the equipment of permanent and temporary airfields for land-based military aviation is to a considerable extent also valid for airfields for helicopters and seaplanes, especially in particular the service and equipment and living areas. For this reason, as we proceed to introduce the reader to airfields for helicopters and seaplanes, we feel it necessary to say that we will confine ourselves in this discussion to the analysis of only the most characteristic things for these airfields, and we also note how they differ from airfields for land-based military aviation.

Airfields for Helicopters

As early as 1754, the great Russian scientist M. V. Lomonosov constructed a model of a helicopter which he recommended for use in studying the atmosphere. In the years preceeding the Second World War, helicopters of various types suitable for practical application appeared in the USSR, the USA and in several other countries. However, large-scale application of helicopters to civil and military purposes only began in the post-war years.

Soviet helicopters designed by M. L. Mil', A. S. Yakovlev, N. I. Kamov and the pioneer of domestic helicopter construction I. P. Bratukhin now enjoy great fame throughout the whole world. The helicopters of the American firms of Sikorskiy and Pyasetskiy and the English firm "Bristol" and others are widely known abroad.

The principle difference of the helicopter from the airplane consists in the ability of the helicopter to take off without an acceleration run and to land without a deceleration run, to hang immovable in the air, and to move laterally and backwards. This is conditioned by the principle design difference of the helicopter from the airplane. With the helicopter, the functions of creating lift, pulling forward, and guidance are carried out by one device - the main rotor which replaces the wing, the tractor propeller or exhaust of a jet engine, the elevator, the rutter and the aileron of the airplane. In case of need, the helicopter can take off vertically from the ground and land (also vertically) on an area hardly larger in dimensions than the area described by its main rotor. For that reason many people believe that in general it is not necessary to have a specially constructed airfield for helicopters.

Unfortunately, this is not true, all the more so when one speaks of large-scale application of helicopters to military purposes. When carrying out missions for the assault of troops, for the transporting of military cargoes or the evacuation of wounded, helicopters in the majority of cases do not need specially constructed airfields. However, airfields are necessary to provide for permanent or temporary basing of helicopter units and elements.

In order to determine in what respect airfields for helicopters differ from airfields for airplanes let us familiarize ourselves in more detail with the pecularities of takeoff and landing of modern helicopters.

The take-off of the helicopter can take place vertically, along an ascending flight path with progressive velocity, and like an airplane.

The vertical takeoff is the least economical in the expenditure of fuel and for that reason it is used only if it is impossible to utilize other methods. The take-off airplane-like consists of the following stages: accelerating on the ground, gaining an altitude of 2-7 meters and acceleration in flight. It is adopted for takeoff with a heavy payload and in those cases when it is necessary to compensate for the reduction of lifting force at high mountain airfields or at high temperatures when the density of the air is less than normal. The basic method of takeoff is along the ascending flight path. It consists of three stages: lift-off from the ground, vertical gain of altitude to 2-7 meters, and acceleration with an increase of altitude and progressive speed. The takeoff along an ascending flight path and the airplane-like takeoff are carried out against the wind.

The landing of the helicopter may be carried out in two methods: as a helicopter, i.e., vertically, and as an airplane. In landing as an airplane, the helicopter goes through all the landing stages which are characteristic of an airplane: gliding, leveling out at an altitude of 5 to 10 meters, airborne deceleration, and landing. The chief method is landing as a helicopter. The helicopter descends along an inclined flight path to an altitude of 25 to 50 meters, then along a curved flight path to an altitude of 5 to 10 meters until the moment of stalling. After stalling, the helicopter descends vertically to the landing area.

As can be seen from the above, it is necessary to have a landing field of sufficient size at the airfield for helicopters. In a combat situation, helicopters operate as a rule in groups and consequently take off and land in groups. For that reason, the dimensions of the landing field of the airfield should permit the possibility of simultaneous takeoff (landing) of a group of helicopters, where the distance between helicopters of the group for purposes of safety are generally not less than 2 to 3 diameters of the main rotor.

Class three permanent airfields are generally utilized for long-term basing of helicopters while third class temporary airfields or specially constructed areas for helicopters are used for short-term basing, a landing field of which is laid out in a square.

The airfield (area) for helicopters has all the elements of an airfield: landing field, service and equipment area, living area, airfield-contiguous territory with landing approach areas.

It is characteristic for the landing field of the airfield for helicopters that, as a rule, there is an absence of synthetic surface. Individual places are usually prepared for parking the helicopters which must

have securing points for mooring. The parking places are connected to the landing field by taxi strips. Radio and light-signal equipment is found in fewer numbers and simpler form than on the airfield for airplanes. The service and equipment area and the living area of such airfields do not have any principle differences from the corresponding areas of the airfield for airplanes.

Airfields for Seaplanes

Seaplanes which were adapted for use for military purposes appeared before the First World War. The leading role in the creation of seaplanes belongs to the Russian and Soviet aviation designer D. P. Grigorovich. As early as 1914 he constructed a two-place seaplane of the "Flying Boat" type possessing the most excellent flying characteristic for that time: speed - 128 kilometers per hour, ceiling - 4,450 meters, duration of flight - five hours, payload - 300 kilograms. This airplane was adopted by Russian aviation. In the years of the First World War, D. P. Grigorovich created an even more modern seaplane, the M-9. During the period of the Civil War and the War of Foreign Intervention, the M-9 seaplane successfully carried out red air raids. West European designers were also unable at that time to create a seaplane up to the quality of the M-9 seaplane. In 1917, the provisional government gave licenses to construct this seaplane to the allies of the First World War.

At the beginning of the Second World War all naval flotilla which had their own aviation had seaplanes for reconnaissance and patrol duty. In the first postwar years the interest in seaplanes in the leading countries of the world dropped off in comparison with the rapid development of land-based aviation and the addition to it of jet aircraft. In the last few years, seaplanes have acquired more and more intense attention of military aviation specialists. The basic reason for this is the difficulty of providing modern land-based aviation with airfields. In the opinion of specialists, there is the possibility of wide utilization of closed reservoirs, rivers and ocean bays which are protected from winds for the creation of seaplane landing areas, especially since the possibility of construction of a large number of modern, large land-based airfields is considerably limited in a number of areas. It must not be forgotten, however, that in a number of areas including the majority of areas of the USSR, the closed reservoirs, rivers and coastal regions along the sea freeze over in the cold season of the year.

Seaplane landing areas - this is an airfield for seaplanes. The basic element of the seaplane airfield is the water area which is a part of the reservoir which is specially equipped for take-off, landing, taxiing, parking and servicing of seaplanes, and also for the movement of

floating facilities. The second element of the seaplane airfield is the coastal sector adjacent to the water area. Here are distributed the service and equipment zone and living area of the seaplane airfield. The makeup and equipment of these areas are the same as for land-based airfields if we ignore the special moorings, the equipment for launching the seaplanes from the land into the water and hauling them onto the land for parking, the technical servicing and repair, and likewise the places equipped for parking and taxi strips. All of this is located in the service and equipment zone. The seaplane airfield, just as a regular airfield, has an airfield-contiguous territory.

Seaplane airfields can be on the ocean, on legs, or on rivers. According to the degree of equipment, they are subdivided in the same way as regular airfields into permanent and temporary while according to the dimensions and some other special characteristics of the water base, they are divided into three classes.

Inasmuch as the basic difference of the seaplane airfield from the regular airfield consist in the presence of the water area, let us investigate this element more thoroughly.

Seaplane Airfield

The water area of the seaplane airfield consists of the landing basin, taxi strips and harbor. The landing basin is designed for take-off and landing of the seaplanes. On the seaplane airfields of rivers, the landing basin has the form of a runway and permits take-off and landing to be carried out only in two opposite directions. On the seaplane airfields of the ocean and of lakes, the landing basin usually

has the form of a circle, square or rectangle and permits take-off and landing to be carried out in several directions. The taxi strip is used for taxiing the seaplanes before take-off and after landing. It borders the landing basin with a strip of certain widths. The harbor serves for parking and servicing the seaplanes afloat and also for parking floating facilities for servicing seaplanes. The harbor is directly adjacent to the shore sector of the seaplane airfield.

The water area of the seaplane airfield should have free air approaches in the take-off and landing directions of the seaplanes.

Along with the creation of seaplane airfields, experiments are being undertaken in a number of countries to create floating bases for the servicing and repair of seaplanes in the open sea.

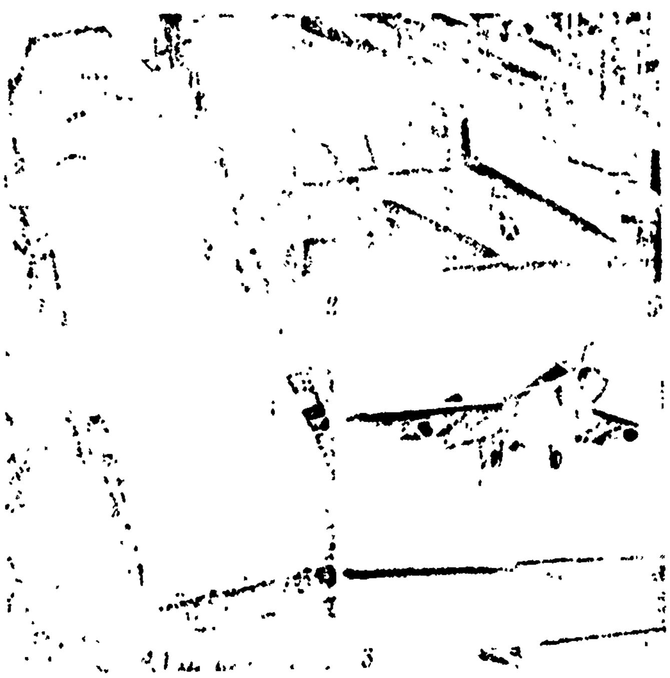
Aircraft Carriers

The aircraft carrier is a combat ship of the Navy designed and equipped for basing so-called floating aviation. In other words, the aircraft carrier is a floating airfield. Planes having special equipment for take-off and landing using the flying deck can be based on aircraft carriers such as fighters, fighter-bombers, reconnaissance planes, antisubmarine planes, and also helicopters.

According to tonnage (displacement) aircraft carriers are divided into heavy and light. Heavy aircraft carriers have a displacement up to 75,000 tons and more, the speed of more than 30 knots (a knot is the speed equal to 1 mile per hour or 1.8 kilometers per hour), a hull length of 300 meters and more, and a complement of 2,500-3,000 men. Such aircraft carriers can carry 100 to 120 airplanes and helicopters. Light aircraft carriers can carry up to 70 airplanes and helicopters, have a displacement of 25 to 30,000 tons, a hull length of 200 to 250 meters, a speed of up to 30 knots, and a complement of 1,000 to 1,500 men.

According to a mission, aircraft carriers are divided into attack, convoy, antisubmarine and helicopter carriers. Attack aircraft carriers (usually heavy) are designed for combat of their own airplanes with the enemy air force in the open sea for the purpose of supporting the missions to be accomplished by the fleet and also for action on objects on land. They are part of the so-called attack carrier formations. The American militarists, for example, make wide use of attack aircraft carriers operations of plunder in Vietnam. Convoy carriers are usually light aircraft carriers designed for aviation support of ocean convoys. Aircraft carriers for antisubmarine defense carries special airplanes and helicopters designed for combat with submarines. Both light and heavy

aircraft carriers may be utilized as antisubmarine carriers. The helicopter carrier (aircraft carrier for helicopters) has equipment for basing helicopters and for quartering marine units on assault missions. Helicopter carriers have appeared in several countries only in the last few years.



Aircraft Carrier:
1, airplane lands with the help of catapult; 2, hangar in hold; 3, landing of aircraft (the landing hook of the airplane and a detail of the deck landing apparatus of the flight deck are visible).

The basic elements of the aircraft carrier as a floating airfield are as follows: flying deck - for take-off and landing of airplanes, hangars - for storing and servicing airplanes (located in the holds of the ship), command points and combat posts from which the control of airplanes and helicopters is carried out. In addition, there are quarters for personnel, storage for supplies of materials, and also a powerful system of defense on the aircraft carrier.

The takeoff of airplanes from the flight deck is carried out with the help of launching catapults located in the nose part of the aircraft carrier. When landing on the flight deck, the deceleration run is reduced to 30-40 meters thanks to the help of the deck landing control device (steel ropes connected with a system of blocks with the braking devices) located on deck. In landing, the airplane seizes the rope with a special hook (tail hook) located in the tail section of the airplane. During take-off and landing, the aircraft carrier usually is moving at maximum speed against the wind. Take-off and landing of aircraft are possible only with ocean waves no greater than three balls.

Aircraft located in the hangars of the aircraft carrier are raised to the flight deck using special elevators (hoists). These same elevators lower them from the flight deck to the hangars.

The most improved aircraft carriers have an angular (oblique) flight deck situated at an angle to the longitudinal axis of the ship. Such a design solution permits constructing a large-size deck and at the same time permitting take-off and landing of aircraft. In the last few years aircraft carriers have been constructed with nuclear engines which guarantee a high degree of independence of movements, and the most recent equipment permits takeoff while the aircraft carrier is standing still.

Airplanes Prepare for Flight

"In order to conquer the enemy in the air, the pilot must do a great deal on the ground". Aleksandr Ivanovich Pokryshkin, three times a Hero of the Soviet Union and one of the most famous air fighters of the Great Fatherland War, wrote this in his book "The Sky War". He went through the war from the first to the last day in uninterrupted aerial combat and personally destroyed 59 enemy aircraft. In each of his victories there was a part of the work of those who prepared the airplane on the ground, who assisted in the preparation of the aircraft with the items necessary for flight and combat, who worried about the health, food and recreation of the airmen under difficult front conditions.

A. I. Pokryshkin began the war as a deputy commander of an aviation squadron and ended it as a commander of an Air Force fighter division. In rendering what is due to his personal bravery, courage and ability in defeating the enemy in aerial combat, it is necessary to render what is due also to his abilities and knowledge as a commander. He personally led groups of fighters into combat and managed the combat activities of the division. Such an air fighter and aviation commander well knows the role and significance of ground support.

What is necessary for the pilot on the ground is first of all what must be done to support, supply and load his plane. Let us familiarize ourselves with the needs of the modern military airplane for basic material facilities both for flight and for the conduct of combat.

What Is Needed for the Airplane?

It is not easy to answer this question. At the airfield, the airplane should receive everything that it expends in flight. And a great deal is expended in flight, not only in quantity but also in variety, or as they say, in the nomenclature of materiel.

The requirement of the aircraft for concrete items of material support depends upon what type of airplane has landed on the airfield, what its mission is, and consequently, what systems it has on board and what material items are expended in flight. From this stems the no less important requirement for personnel working in airfield-equipment support: they must have a good knowledge of the design of modern airplanes and especially the systems which expend materiel, and also what particular material items, in what quantity and quality are necessary for these systems.

In order to explain more concretely what the airplane needs it is

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necessary to remind ourselves in general and unrelated to any particular concrete type of aircraft of the basic systems of the airplane which require materiel in flight. Let us say a few words about the requirements of military aircraft duri .g the period of the First World War.

The requirements of aircraft of this period were determined by the presence of the following systems: fuel system (gasoline), lubrication system (castor oil), engine cooling system (water). In addition, depending upon the aircraft mission, there was a requirement for ammunition for machine guns, bombs, film for hand-held cameras which were used in reconnaissance.

Fifty years have passed and this is the kind of list we might make up of the basic systems of the modern military airplane.

Fuel system (gasoline, aviation kerosene). Auxuliary tanks (so-called suspension tanks) have found widespread use in the system. These tanks may be jettisoned in flight, i.e., expended, and therefore also are one of the types of materiel necessary to the airplane. The fuel system requires topping up with fuel after each flight and sometimes after ground testing of engines.

Lubrication system (aviation oil of special types including summer and winter). The obvious purpose of this system consists in supplying the moving parts of the engines aircraft with lubrication. The amount of oil used up, as a rule, is not significant but it is necessary periodically to top-up the system on the ground.

Hydraulic system (mixture of glycerine with alcohol, mineral oil, and special liquids). The system is designed for putting in motion various assemblies and devices on the airplane: raising and lowering the landing gear, opening and closing hatches, operating the wheel brakes and air-brakes, controlling the assemblies of the mechanisms of the wing (deflectors and flaps), etc. A systematic expenditure of liquids during flight does not take place and for that reason the system has to be topped up or refilled only periodically.

Air system (compressed air). This system carries on basically the same functions as the hydraulic system. Modern aircraft in most cases have an emergency or second system duplicating the hydraulic system, but which is used as a basic system (for example, for reloading weapons, operating the de-icing device, ejecting the cabin canopy and for hermetically sealing it). This requires a systematic refilling on the ground from outside sources.

Oxygen system (gaseous or liquid pure oxygen). Provided to support the crew during high altitude flights which now have become usual for combat aircraft. In a number of cases the oxygen supply of the crew is connected already on the ground before takeoff. The system requires refilling after each flight. When being used the system of liquid oxygen needs periodic refilling and also must be refilled when the aircraft is on the ground because a steady evaporation of oxygen takes place from the aircraft's system.

Air conditioning system. The system is provided to maintain the hermetic condition of the airplane cockpit within certain limits of pressure, composition, temperature and humidity of air necessary to sustain the life of the crew at high altitude flight. The system consists of a number of sub-systems and special devices which operate during flight. However, under certain conditions the necessity arises of air conditioning the cockpit of the aircraft when it is on the ground. Special machines called air conditioners do this.

De-icing system (compressed air, alcohol, antifreeze). This serves to prevent the icing of the aircraft and removing ice during flight. Depending upon the design of the system, the above-mentioned materials are used. In addition, it may be a thermal system operated by electricity or hot air. The liquid and air systems must be refilled after each use of the system in flight.

Fire-fighting equipment (carbon dioxide gas, nitrogen, special liquids). This consists of a system of filling the fuel tanks with a neutral gas and a system of smoothering a fire in the engines. Bombers and military transport aircraft (helicopters) also use portable fire extinguishers. A system of neutral gases requires refilling after each flight, especially under combat conditions. The system for extinguishing a fire in the engines and the portable fire extinguishers are refilled after use in flight.

In addition to the basic systems mentioned above, modern aircraft have various equipments (radio, radio-technical, light, reconnaissance, etc.). Some kinds of this equipment are also consumers of materiel. For example, the photographic equipment requires a large quantity of wide format aerial film which is consumed during each reconnaissance flight. The system for interfering with the enemy's radio and electronic equipment also requires a large quantity of special reflectors. Other kinds of equipment are consumers of a large quantity of electric power. If energy from on-board sources is used in flight, then ground sources have to be connected to the airplane on the ground. Direct and alternating electric current of various voltages and power are also needed to check the equipment and systems of the airplane and also for starting the engines.

For all practical purposes modern military aircraft no longer use engines having liquid cooling, but there was a time - the pre-war period and the wars of the Great Fatherland War - when such engines were widely used. A large quantity of water or antifreeze was required to service them, which caused great difficulties in the winter.

The nomenclature of destructive devices used by modern airplanes has significantly increased. These are ammunition for machine guns and cannons, aerial bombs, guided and ballistic rockets, tanks with combustible liquid and many others. All these items of destruction are consumed completely or partially during every combat flight and it is necessary to replace them at the airfield after landing.

These are the potentially possible requirements of modern airplanes for various materiel. And inasmuch as military airfields must supply the needs of every type of aircraft which the size and equipment of the landing field will permit, every airfield must be provided with all of this materiel and also with sources of power.

It is necessary to take into account one more circumstance. The requirements for materiel are not limited only to what is expended during the flight, even though these are the chief requirements. In addition to these, the need arises to repair aircraft and to carry out adjustments, and this calls for so-called aviation supply stores, the nomenclature of which now encompasses hundreds of thousands of named items beginning with the engine and ending with safety wire and cotter pins. However, the need for this kind of materiel is not directly connected with each flight.

Thus, we have already partially answered the question posed at the beginning of this section of the book by showing the possible requirements of modern aircraft for parts of the nomenclature of the necessary material items only. The quantity of expendable items is probably also of interest to the reader. This is defined as the consumption of these items during one flight. It is well known, for example, that the airplane lands always having a certain residual amount of fuel in the tanks. As a rule, not all of the oxygen and compressed air is completely consumed during the flight. Other items (for example, cartridges and rockets) may be completely consumed. As a rule it is forbidden to land on the airfield with bombs. For that reason, even if the bombs were not dropped on the target, they must be jettisoned before landing, but not necessarily armed. The airplane must approach the airfield without bombs.

The consumption of material-technical items during the flight is calculated using special units. One of these is the "airplane flight". Let us explain how this unit is used in calculating the consumption of

fuel. Assume the airplane is completely filled with fuel (accepting this as not related to any particular aircraft type) and this came to 1,000 liters. This value, by the way, is also used in the calculations as a unit; it is also called "refueling". Let us assume that the airplane consumed 85% of its fuel during its flight. Consequently, the coefficient of consumption of fuel for the flight is equal to 0.85, and the consumption of fuel for one airplane flight, as units (they even say - cost of the airplane flight), is equal to 850 liters (1,000 liters × 0.85). Thus, in order to support the aircraft which has landed at the airfield and which took off from it with 1,000 liters of fuel, 850 liters of fuel are required. This is very important for specialists calculating the requirements not for one but for hundreds of aircraft or aircraft flights. The difference in our example between the fuel load and the cost of the airplane flight (150 liters) in the calculation for 100 airplanes already comes to 15,000 liters.

Specialists of airfield-technical support use the aircraft flight as a unit of calculation for solving, for example, this problem: how many flights for an aircraft of a given type can be supported by the reserves of fuel available at the airport? This is a concrete example. Let us assume that at the airport there are 100,000 liters of fuel and that the fuel capacity of the aircraft for which this fuel is intended is equal to 1,000 liters. How many combat aircraft flights could be carried out on the basis of the available fuel supply? The aviation commander, as a rule, will answer that 100 aircraft flights can be carried out (100,000:1,000 1). The specialists of airfield-technical support will answer that the number of aircraft flights depends on the coefficient of consumption of fuel in flight. With the coefficient of 0.85 it is possible to carry out 117 (100,000:850 1) flights.

The difference of 17 flights may not seem to be significant. For conditions of peacetime and at a permanent airfield with large supplies of fuel this actually is not very large. However, under combat conditions at a temporary airfield which is supplied with fuel only with great difficulty, such a difference has a very real significance. For this reason, specialists of airfield-technical support under such conditions scrupulously consider the availability and consumption of fuel as well as all other material items. It would be easy and simple to estimate the consumption of fuel if it weren't for one serious circumstance: who provides the specialists of airfield-technical support with the assumed coefficient of consumption? Only an aviation commander planning combat operations can do this. Knowing the mission, targets of operation and distance to them, he can (with the help of the navigator and engineer) determine the need for fuel for the planned flight and, comparing this with the volume of fuel in the aircraft's own system, indicate the

coefficient of consumption. However in flight, and all the more so in combat operations, different circumstances quite often arise which increase the consumption of fuel but which the aviation commander cannot always foresee. For this reason, in estimating the need for fuel over an extended flight, he must also consider some kind of reserve for unforeseen circumstances. As a result, the coefficient of consumption of fuel calculated by the aviation commander is not sufficiently accurate. Here experience in combat operations, statistics, and theory of probability are of some assistance. But even with their help it is not always possible to resolve the problem with the necessary degree of accuracy.

Similar to the way in which the total requirement of the airplane for fuel is determined, the requirements for other material items are also determined. For example, the following are used as initial calculating units: for means of destruction - "combat complex" (combat complex of cartridges, combat complex of bombs, combat complex of rockets), for gases - "total charge" (total charge of oxygen, total charge of compressed air, etc.), for suspension tanks - "complex". Each of these units according to its own content makes up the quantity of one or another item which can be loaded on a concrete airplane according to its own technical specifications. For example, the complex of suspension tanks of the aircraft - two tanks, the charge of oxygen - seven liters, etc. Knowing the coefficients of consumption in flight of each kind of material item, the necessary quantity of these items to support all aircraft which must land at the airfield can easily be determined.

In practice, no one and nothing can guarantee that during the time of flight the assumed quantity of material items will be expended on the airplane. Moreover, in a group of airplanes carrying out one flight or one combat mission, the consumption of material items of the same type may be more or less than assumed for each individual aircraft. Therefore, after the aircraft lands it is necessary to determine what concrete material items and in what quantity are needed for each of them. Here specialists of airfield-technical support come in contact with specialists of engineering-aviation support or, to say it more simply, with the engineering-technical structure of the aviation unit under control of which the airplane which has landed at the airfield now comes.

The preparation of the airplane for flight at the airport occupies many specialists who use a significant quantity of different equipments and technical means. According to information of foreign aviation magazines, 20 to 40 specialists of ground support and up to 10 special machines take part in the preparation of a single aircraft, not counting individual control devices and sub-systems. It must not be thought that every military aircraft or flying crew on the ground has the indicated

number of specialists and machines. One and the same specialists and machines participate in the preparation of many airplanes, but in the preparation of each of these exactly that number of them participate.

The number of specialists and machines necessary for the preparation of an airplane depends on exactly what kind of airplane is being prepared. For example, a significantly smaller number of personnel and resources is needed to prepare a military transport airplane than to prepare a bomber. There is a very marked tendency in our day towards complication in the design of military aircraft, increase in the number and variety of equipments on them, complication of these equipments, increase in the types of destructive devices used on airplanes, and this tendency also conditions the tendency to an increase in the number of ground service personnel and also in the number and complication of the technical facilities used in servicing. This tendency in turn causes more and more narrow specialization of the ground service personnel and in particular a limitation in the function of specialists of the engineering-aviation service and specialists of the airfield-technical support.

We did not set outselves the goal of reviewing the functions of the specialists of the engineering-aviation service and the order of carrying out their work in servicing the airplanes. We only note that these specialists determine the concrete needs for each kind of material item in the process of checking the condition of all systems of the airplane which has landed at the airfield and in determining its suitability for regular (in aviation it is called - repeated) flight. It is the responsibility of the specialists of the airfield-technical support to furnish the airplane with the required items and to fill up (charge) the airplanes systems with those items with the help of special machines. These machines are usually called facilities for ground flight support[1]. Along with the items used for filling up (charging) the airplanes systems, the airplane is also supplied with electric power necessary to check the systems and the equipment of the airplane, the air conditioning, prime movers, and other items.

In checking the airplanes systems and equipment in the process of determining the suitability of the aircraft for flight, the specialists of the engineering-aviation service make very intensive use of two kinds of facilities: sources of electric and hydraulic energy. Let us familiarize ourselves in more detail with these facilities of ground flight support in their modern form.

[1]The name "facilities for airfield-technical support" is also used.

Thus the Magazine "Stern" (Federal Republic of Germany) Pointed Out that a Large Number of Specialists of Ground Personnel Take Part and Many Technical Facilities Are Used in the Preparation of an Airplane. The figures designate the following:
1, tractor; 2, oxygen charging station; 3, instrument for checking the radio equipment; 4, airfield electro-system; 5, lifting hoist; 6, [missing]; 7, vehicle for transporting ammunition; 8, refueling system; 9, fire truck; 10-19, [missing]; 20, equipment for checking the aircraft's engine; 21-22, [missing]; 23, technical personnel; 24, fire fighting crew; 25, personnel of the landing support system; 26, aircraft technician; 27, pilot.

Special, airfield portable electric generators are used on the airfields of military and civil aviation as sources for electric power. In the USSR it is usual to place them on the chassis of trucks. In other countries, for example, in the United States, generating assemblies which are constructed in the form of twin-axle trailers which are drawn by prime movers are quite widespread.

Airfield transportable electric generator assemblies should supply the airplane's systems and equipment with electric current having various parameters, and they are quite complicated devices. The special

equipment APA [Tr. Note: electric generator equipment] has a generator for direct current, a rectifier for changing direct current into alternating current, storage batteries, commutator and protective apparatus, control panels and a control for the supply of electricity, power cables for alternating and direct current for supplying electric power to the systems of the airplane. The drive for the direct current generator is either supplied by the engine of the truck on which the assembly is mounted or by a special motor. The electric generator assemblies are used for supplying electric power to the users of power on the airplane with the resolution of two basic problems: starting the engines of the airplane and checking the systems and equipment working off electric power.

It is necessary to add that the requirements for electric power for the systems and equipment of the modern aircraft are extremely various and rigid. In order to operate the radio, radio-technical and aviation facilities installed on the aircraft (systems of electric power supply, light-signal facilities, control devices for the flight routine, and others not belonging to the radio and radio-technical equipment) and also individual elements of the hydraulic and fuel systems of the aircraft, different electric current both in kind and value are required: direct current, mono-phase alternating current, three-phase alternating current, all of different voltage and frequency.

In order to receive current of all these types, corresponding electric generators and rectifiers are found on board the airplane. Storage batteries are an emergency source of current, but sometimes they are used for independent starting of engines on the aircraft (i.e., without using ground sources of electric power). These batteries need periodic charging from ground sources, and special battery charging stations are used to do this. They are also items of ground flight support. In special cases, it is possible to charge the batteries from portable electric devices.

Special devices for checking hydraulic systems (UPG) [Tr. Note: Ustanovki Proverki Gidrosistemy] are used for supplying these systems of the plane with hydraulic power. At the present time, the majority of airplanes use hydraulic devices for raising and lowering landing gears, flaps and air-brakes and for controlling rudders, landing brakes, etc. These devices operate under pressure of a liquid flowing to them from hydraulic pumps installed in the aircraft engines. The hydraulic systems operate under conditions of changing pressure of liquid from zero to 250 kg/cm^2 and more and temperatures from -60 to +100°C and higher. Naturally, special liquids which satisfy a number of rigid requirements are needed to operate under these conditions. Thus, for example, the

liquid must have low viscosity which changes little with a change in temperature; low freezing temperature and high boiling point; it must not have any injurious effect on working parts and sub-systems of the system, especially hoses. One of these liquids is AMG-10 which is widely used in our aviation.

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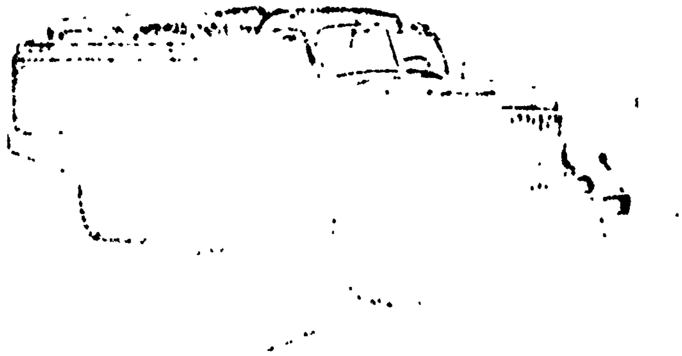

Equipment for Checking the Hydraulic Systems of the Aircraft (UPG).

The equipment for checking the hydraulic system (UPG) is also used for checking the condition of the airplane's hydraulic systems and hydraulic sub-systems when the aircraft engines are not operating, and for checking and charging the hydraulic systems with operating liquid. Often, for example, the operating capability of the system for lowering and retracting the landing gear of the airplane is carried out using the special system for checking hydraulic system (UPG); to do this the airplane is raised on special hoists. One of the most important requirements demanded of the liquid is purity, the absence of any mechanical admixture in it. Sub-systems and working parts of the hydraulic systems working under high pressure operate with close tolerances. If the slightest particle of dirt, metallic shavings or other admixtures should enter the systems, the system can break down and consequently the airplane may not operate.

In the last few years, combined facilities for ground flight support have acquired wide usage. These facilities combine in particular the functions of supplying electric power and hydraulic fluid to the aircraft systems in the process of the check-out at the airfield. This is the so-called electro-hydraulic equipment (EGU). It is usually mounted on a truck chassis or trailer. The above-mentioned electrical sub-systems

and hydraulic equipment similar to the special device for checking hydraulic systems (UPG) make up the special EGU equipment. The latter consists of a hydraulic pump driven by the truck engine or by a special motor of the equipment, a filter for removing metal particles from the liquid, a radiator for cooling it while the liquid pressure regulator is operating, a control panel and hydraulic systems control, and high and low pressure hoses for supplying the liquids to the airplane's systems. Some electro-hydraulic equipments (EGU) also have an air-pressure system used for filling up certain of the airplane's equipments with compressed air and also for the EGU itself, and also for charging individual elements of the hydraulic system of the airplane (shock absorbers of the landing gear, liquid storage batteries, etc.) with compressed gas at various pressures.

In the special APA, UPG and especially in the EGU equipments, there are many sub-systems and working parts similar to those installed on the aircraft. Only highly qualified specialists should operate these equipments. Proper use of the machine and its special equipment is not possible without a knowledge of the physical symbols used in the field of electricity, hydraulics and gas and without a knowledge of the properties of liquids and gases used in operating the sub-systems.

Practical experience in the use of electrical devices shows what can happen with unskilled or careless handling of electricity. Unskilled or careless handling when working with the EGU can lead to serious consequences not only for the specialists using the equipment but also for the airplane, the pilot and specialists of the engineering-aviation service.

The matter of using the special hydraulic and air-pressure devices of the equipment is just as serious, since, as a rule, similar equipments are not found in everyday life and people do not have even the vaguest notion of how to handle such devices and sub-systems.

There are two reasons for malfunctions in electrical circuits and devices: lack of contact where there should be contact and presence of contact where it should not be. The second reason is especially dangerous, and it can lead, for example, to short circuiting and fire or to the current burning people who have "contact" with the circuit. Careless handling of hydraulic or air-pressure equipment operating as a rule at high pressure and temperature can lead to the bursting of pipeline conduits, devices and sub-systems and to the breaking and destroying of individual points and parts, to the damaging of liquid or gas jets coming out of the damaged pipeline conduit or from hoses and pipeline conduits for supplying the systems of the aircraft.

Accomplishing the check-out of the airplane's systems using APA, UPG or EGU requires the chief mechanics to be not only very knowledgable but also highly disciplined in the operation of the equipment, and also requires coolness, precision, and speed (but not bustle) of carrying out the necessary operations. The truck (sub-system) must be parked at a strictly determined place depending on the type of airplane. After the truck has been set up and the brakes applied, the chief should carefully ground it by means of a special device, feed the cables or hoses to the aircraft systems (its equipments) to make connections and at the command of the mechanic (technician) of the airplane, he should connect the sub-systems of the truck to supply the systems of the aircraft with power. It is very important to maintain the necessary parameters of electric power running from the truck into the aircraft systems. It is just as important to watch over the condition of the special equipment of the truck and over the parameters of the liquid and compressed air. Thus, for example, the liquid AMG-10 must not be allowed to exceed a temperature of 90°C because the liquid might ignite on coming in contact with the hot parts or from a spark (for example, an electric spark), and the probability of such a formation in an electro-sub-system is very probable. There are, of course, other limitations, requirements, and rules which the chief of the truck must observe in the process of its work. It is not our aim to address these in detail. With the examples cited here we only wanted to emphasize and confirm the necessity for high qualifications of the proper specialists of airfield-technical support, the responsibility and difficulty of their work on modern technical facilities designed for assisting the preparation of aircraft for flight.

Having acquainted ourselves with what is necessary for the aircraft and the part that is played by specialists of airfield-technical support in checking the condition of the aircraft systems and the suitability of the aircraft itself for flight, let us now consider how these requirements of the aircraft for basic material items are satisfied.

Fueling the Aircraft

In practice it is possible to lift an airplane into the air and even to carry on aerial combat even in that case when there are no material items necessary for normal flight and carrying out combat operations on board. During the Great Fatherland War, many a Soviet pilot, when his ammunition on board had run out, or his guns had malfunctioned, had adopted a ramming technique, knocked down the enemy aircraft and afterwards landing safely.

The airplane becomes powerless when it has no fuel. Fuel is the source of power for flight without which the airplane is dead. For this

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reason, if the airplane is technically in order and suitable for flight it should first of all take on fuel. By weight and volume fuel occupies the first place among all the material items with which the airplane must be supplied at the airfield.

Remember how the famous Civil War military leader, V. I. Chapaev, complained about the excessive consumption of gasoline by the airplane sent to his division. But in comparison with the fuel requirements of todays aircraft, the requirements of aircraft of the Civil War period was a drop in the bucket. In our day, military jet aircraft devour a tremendous quantity of fuel. The table shows the range of fuel requirements for aircraft at three periods in the development of aviation.

Aircraft	Volume of fuel tanks aboard aircraft in liters in different periods of aviation development		
	1914-1920	1941-1945	1960-1967
Fighters	60-100 ("Farman" and "Newport")	350-450 (Ya-3, La-5)	5000 (F-104)
Front (tactical) bombers	200-300 ("Voisin"	1500-2000 (Pe-2, Tu-2)	8000 ("Canberra")
Heavy bomber	700-800 ("Ilya Murovets")	4000 (Il-4)	140,000 (B-52)

As can be seen from the table, the volume of fuel systems of modern fighters has increased ten times and front (tactical) bombers 4-5 times, while heavy bombers, or as they are now called, long-range or strategic bombers, more than 30 times!

These figures also show how much the amount of work has increased in the airfield-technical support of military aviation in the field of providing fuel alone. Specialists in airfield-technical support build up a reserve of fuel at the airfield and maintain it at a certain level. Since fuel is continuously being consumed, the fuel reserves must be constantly replenished. It is a difficult job to maintain a large amount of fuel in storage, and all the more so in storage at a temporary airfield not equipped in appropriate fashion and subject to the constant threat of enemy action. Additional difficulties also arise owning to a number of negative properties of the fuel itself - especially jet engine fuel. At the present time a ligroin-kerosene fraction of petroleum is

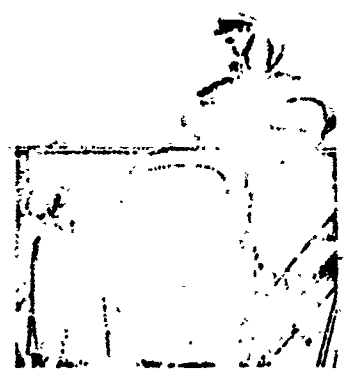
used for such a fuel (sometimes it is called aviation kerosene). In the Soviet Union, this fuel is called T-1, TS-1 and T-2.

This type of fuel is stable in storage and may be stored for a number of years under normal conditions without a change in quality. However, it is hydroscopic, i.e., is capable of ingesting water from the air and dissolving the water in itself. The amount of water dissolved in the fuel depends on the temperature and humidity of the air. With an increase in humidity and constant temperature, the amount of water in the fuel increases. Also, the process of saturating the fuel with water from the air takes place very rapidly. With an increase in temperature and constant humidity, the solubility of water in the fuel increases, and the fuel begins to abstract water from the air. With the lowering of the temperature, the solubility of water in the fuel drops, and the excess partially evaporates and partially precipitates in the form of an emulsion and thus remains. In addition, metallic impurities may enter the fuel being kept in storage: these are products of the erosion of the container, sand, dust, metallic and rubber particles from the input and exhaust hoses dropped in the containers, etc.

Water and metallic impurities are the most dangerous enemies of the airplane's fuel system. Assemblies, sub-systems and working parts of the fuel system are manufactured with great accuracy, their tolerances are extremely close (5-10 microns), and the diameter of the canals is measured in tenths of a millimeter. Even a slight impurity can impair their work. When the temperature of the fuel is below zero (remember that an altitude of 10,000 meters the air temperature is practically constant at -50°C) any water present in the fuel will freeze and is transformed into ice crystals which can stop-up the fuel system. Water dissolved in the fuel promotes the corrosion of working parts of the fuel apparatus, interferes with the proper lubrication of the fuel pump which leads to the breakdown of these parts. Of course, the fuel system on board the aircraft has filters, but even they might freeze over. These are precision filters which catch metallic particles 7-10 microns in size which may appear within the system itself as a result of natural wear of hoses, lining, and metallic and corrosion wear of working parts of the apparatus. There will not be many of these particles if the airplane is filled with clean fuel.

There are difference methods and means of refueling depending on how much fuel the airplane needs: 50-100 liters (at the dawn of the development of aviation) was poured in using a pail and funnel; several hundred liters (later on) using a hand pump; thousands of liters (now) using refueling trucks.

At the present time, pumping fuel into the airplane is accomplished using special vehicles - refueling equipment (TZ) mounted on a truck chassis or on a trailer (semi). The special TZ equipment consists of a tank for fuel, a system of pipelines and hoses with accessories and control measuring devices, fuel-line filter and pump driven by the truck engine or special-purpose motor. The tank is hermetically sealed and has a safety valve for equalizing the inside pressure with the atmospheric pressure. The lower part of the tank must have a sedimentation tank in which water and metallic impurities are collected. The sediment is drained off through an exhaust hose having a valve. The fuel in the TZ is usually filtered twice: in the intake line through a coarse filter and filter screen (they protect the pump of the TZ from damage), and in the pressure line through a precision filter (it protects the pump of the TZ from mechanical impurities and water). In addition, there is a filter screen at the output valve through which the fuel is pumped into the airplane.



This Is How they Refueled Airplanes.

Using the special equipment, the TZ can

- fill up its tank through the input hose using its own pump (fuel does not filter);
- distribute fuel from its tank through 2-4 output hoses (fuel is filtered);
- transfer fuel from one auxiliary reservoir to another, bypassing its own tank (the fuel may be filtered or unfiltered as needed);

- transfer fuel from its own tank to an auxiliary reservoir (fuel is not filtered);

- mix fuel in its own tank or in an auxiliary reservoir (fuel is not filtered);

- draw fuel from the output hoses (fuel is not filtered).

Refueling Equipment for the "Antaeus".

TZ similar to that described are used in military aviation of various countries, but they have several minor differences: different tank capacity, number of operations to be accomplished, dimensions, installation of pump drive, etc. Thus, for example, it was reported that an TZ was demonstrated at the Aviation Show in Paris whose tank capacity was 45,000 liters. With fuel it weighs 60 tons, is 16 meters long, and the distribution system has a capacity of 1,700-2,500 liters per minute. It must be said that the tank-based TZ differs basically in tank capacity. The TZ is selected according to the capacity of the fuel system of the airplane which is intended to be refueled. In addition, the TZ cannot be utilized under all circumstances. Thus the refueling equipment mentioned above could hardly be used at a temporary airport owing to its inability to handle bare earth and front (tactical) roads. The high fueling capacity of the pumps of the refueling equipment also cannot always be utilized effectively since frequently the pumping rate of the fuel from the TZ into

the fuel system of the airplane is limited by the pumping rate which can be accommodated by the system, i.e., the amount of fuel which the system can accommodate (take in) per unit time. The receiving capacity is defined by the number of fuel tanks which the designers, trying to save space, position at various places in the airplane and connect one another with pipelines, a number of filters and other sub-systems of the system which slow down the passage through it of the incoming fuel.

The filling is accomplished through the fuel hatch of the tank (or tanks). Sometimes refueling is carried out under pressure using a hermetically sealed connection of the distribution hose of the TZ to the fuel hatch of the airplane. This accelerates the refueling, reduces fuel losses from spillage and evaporation. But there is a danger of deformation or even destruction of the aircraft tanks when the fuel vents are not in order.

The filters of the mobile (vehicular) refueling equipment usually only hold back metallic impurities, water which has separated, or ice crystals. Water in emulsion as well as water in solution are not filtered out by these filters[1]. For this reason, the fuel is carefully and frequently checked before filling the TZ, while in the TZ, and while filling the aircraft. Workers of the supply service checks the fuel in special laboratories, which must be located at each airfield. It is also checked by specialists of the engineering-aviation service before filling the airplane with fuel. The fuel must meet the standards adopted for various aspects (density, viscosity, percentage of different fractions and elements, etc.). If any deviation from the standard is found, the fuel is considered sub-standard and is not used for fueling aircraft.

The most dissatisfaction arises usually as a result of the presence of water dissolved in the fuel and less often as a result of mechanical impurities. Special liquid additives which prevent the formation of ice crystals and which quickly dissolve any crystals present or added to the fuel as a means of combatting water (more accurately, the crystallization of water). In the winter, the simplest method of removing water is removal by freezing the water in the container at the storage point before filling up the TZ.

Therefore, on the way from the storage points to the airplane, specialists of aerodrome-technical support and engineering-aviation service set

[1]Designers of many countries are working hard on the development of highly effective filters for the TZ, and the results of this work are kept strictly secret, which indicates the importance of the problem.

up powerful filters and control checks on the fuel with the aim of passing only that fuel to the airplane which completely satisfies the requirements of the standards and flight-safety conditions.

But finally, the fuel is checked, is found suitable and is pumped into the airplane refueling equipment and brought to the airplane. A process of refueling the airplane now begins; the technique of refueling is fairly complicated.

A minimum of two people carry out the refueling: the mechanic .r technician of the airplane and the chief of the refueling equipment. It requires a sufficient skill to be able to drive the modern refueling equipment quickly to the airplane at a definite place so as not to damage the airplane and still be able to reach the fueling hatch of the plane with the fuel dispensing hose. If the airplane has suspended fuel tanks, it is sometimes necessary to drive up to it twice from different sides. After the refueling equipment has been parked near the airplane, the chief passes the dispensing hose to the mechanic (technician) and he himself goes over to the special equipment control cab which usually is found in the rear of the TZ. On command from the mechanic, he connects the pump and pumps the necessary amount of fuel into the airplane's system. The amount of fuel pumped is kept track of by a special liter gauge installed in the refueling equipment control cab. When the transfer of fuel is finished, the chief of the TZ recovers the dispensing hoses (plural, because refueling from one TZ can be carried out using two or even four hoses) and drives the refueling equipment away from the airplane. That is all! The refueling of the aircraft has been accomplished. It remains to tell the reader who is interested in the details of the technique of refueling airplanes about one important circumstance.

There is a potential danger of starting a fire when refueling an airplane, and not because the people doing the refueling violates the admonition - the order "No Smoking"!, but because charges of static electricity form on the airplane and on the refueling equipment. It is well known that the airplane acquires an electrical charge in flight which is distributed over its surface. Since the aircraft is well insulated from the ground by rubber tires, then when landing, for example on a dry concrete runway, this charge may be preserved for a considerable length of time. A static electrical charge can also be picked up by the airplane on the ground. During the test of a jet engine, hot gases moving at high velocity along the gas channel of the engine puts a charge on the plane. During a long deceleration run or taxiing, negative charges may appear on the landing gear cover, while positive charges develop on the metallic parts of the plane lying adjacent. Static electricity also occurs on the refueling equipment, chiefly as a result of the friction of

the fuel in contact with the walls of the container and pipelines. It is noted, for example, that T-1 fuel flowing along the pipeline of an TZ at a rate of 90 liters per minute creates an electromotive force of 6,000-7,000 volts between the fuel tanks of the airplane and the nozzle of the dispensing hose. A potential of only 300 volts is sufficient to produce a dangerous spark in a mixture of fuel vapors and air.

Thus, static electricity is produced on the refueling equipment on the ground as well as on the airplane both in flight and on the ground. When they come close to one another, an electric spark may form directly or through the dispensing hose resulting in a fire. In order to avoid fire during the refueling, the rules for grounding the airplane and the refueling equipment using special devices must be strictly observed. In addition, before beginning the transfer of fuel, the grounded airplane and refueling equipment are connected together: the stake located on the dispensing nozzle (pistol) of the TZ is set up in a special receptacle on the airplane. The grounding collects charges of static electricity from the airplane and refueling equipment preventing formation of sparks. It is only necessary to take care that the grounding wires (plane to refueler) are intacted in all links.

If the necessary supply of fuel is present at the airfield, if there is a proper control over fuel quality, and if certain rules are observed, the airplanes can be refueled with first-rate fuel without any incidence. It is necessary to keep in mind, however, that the aviation commander who has brought his airplanes to the airfield and who is preparing them for subsequent flights is interested in how long it will take to refuel the planes - especially if the planes are on a combat mission. The shorter the time for refueling, the faster the airplanes will be ready for flight and, consequently, the more effectively they can be utilized in the conduct of combat operations. The question of the aviation commander should be answered by the specialists of airfield-technical support who have the fuel stores and refueling equipments at their disposal. To answer this question is to report to the aviation commander the possibility for refueling the planes. How are these possibilities determined?

First of all it is necessary to know how much fuel is require to refuel one airplane and what is the capacity of the tank of one refueling equipment. Comparing these figures, it is possible to establish whether the capacity of one TZ is sufficient to refuel one plane. If this is possible, the matter is greatly simplified - it will not be necessary to send the TZ to the storage point for an additional amount of fuel, which considerably increases the refueling time of the aircraft since it takes extra time for the TZ to drive over to the storage point, replenish its tanks, let the fuel settle in the tanks (mandatory no less than 10 minutes),

and drive back from the storage point to the plane. In this regard it must be taken into account that not all the fuel is pumped from the container of the TZ into the airplane. Part of it remains so that fuel does not get mixed up with mechanical impurities and water in the sediment. Therefore, the usable capacity of the TZ is considered in the calculations (for example, the TZ-200 which is widely used in our country has a tank capacity of 8,000 liters, but its usable capacity is no more than 7,500 liters).

The amount of fuel pumped to the airplane per trip of whatever refueling tank is used can be increased by using fuel tank trailers or vehicular fuel tanks (ATTs). These facilities are for all practical purposes mobile containers from which fuel can be pumped to the aircraft using an TZ.

In the case where the entire amount of fuel required is delivered to the plane in one trip (in an TZ, TZ and trailer or TZ and ATTs) the time it takes to refuel one plane is the sum of the time required for the following operations:

- driving the TZ to the airplane, putting out and taking in the dispensing hoses, driving away from the airplane;

- pumping the fuel from the tanks of the TZ to the fuel system in the airplane.

In addition, when using the ATTs time is required for bringing the ATTs to the TZ and attaching and collecting the TZ input hose to the ATTs.

After the airfield-technical support specialists have determined in practice the time consumed in carrying out each of the above-mentioned operations, they then determine for each type aircraft the total time required for refueling one airplane using various combinations of equipments; TZ with trailer or TZ with ATTs. Therefore it is possible to give an immediate answer to the question of how long it will take to refuel one airplane. But often it is necessary to refuel a group of airplanes and, of course, to determine the time it will take to do this. In this case, the procedure is as follows. When the number of available TZ and the airplanes to be serviced are known, the number of airplanes per TZ is calculated (the result is rounded off to the next whole number). Since the time for refueling one plane is known, the time required to refuel the group can be calculated.

Example. The refueling time for one airplane is 20 minutes. There are 10 refueling trucks at the airfield. Determine the time required to refuel a group of 16 airplanes.

For each refueling equipment there are two airplanes (rounded off). The group can be refueled in 40 minutes, more accurately 10 of the 16 airplanes will be serviced in 20 minutes, and the other six after a lapse of 40 minutes.

If it is not possible to supply the amount of fuel needed in one trip of the refueling facilities, then the time consumed in a second trip of the refueling facility to the fuel dump is added to the refueling time.

In recent years, so-called centralized refueling systems or centralized refueling equipments (TsZ) have found wide usage at airfields for refueling airplanes. Stationary TsZ have been set up at permanent airfields, while mobile (prefabricated sectionalized) TsZ of different varities are found at temporary airfields. The basic elements of both kinds of refueling equipments are the surface or underground fuel dispensing tank, the pumping stations, the pipelines and refueling stands (posts) which have dispensing hoses, filters, liter-measuring gauges, signal devices or automatic devices for turning on and turning off the refueling pumps. In the mobile TsZ complex, the pumping stations and refueling stands can be mounted as individual mobile assemblies, pipelines can be set up and taken down quickly using different schemes, and soft containers made of special rubberized fabric are used as dispensing tanks.

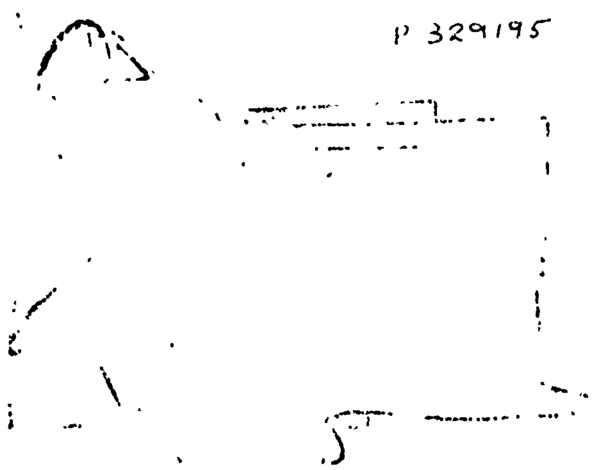
To use the TsZ, airplanes are towed to the refueling assemblies set up at certain places on the landing field.

Charging the Airplanes Systems with Gases

In order to operate certain systems of modern aircraft, a number of gases are used, primarily in the compressed form, e.g., carbon dioxide or nitrogen in the fire extinguishing system (system of neutral gases), compressed air in the pneumatic system of fire control of heavy weapons, and in other systems, oxygen in the oxygen system of the plane. Liquified gases are also used, e.g., liquid oxygen.

The consumption of gases such as oxygen or nitrogen is relatively light and irregular. For that reason, in preparing an airplane for regular flight, it is not mandatory to charge these systems with gases. If there is a necessity, then the systems are charged by passing gas from the airfields cylinders to the on-board system of the airplane. Recently, mobile charging stations are finding more and more frequent use for this purpose. Thus, for example, air-charging equipments (VZ) mounted on a truck chassis are used for charging with compressed air. The special VZ

equipment consists of a battery of cylinders, control apparatus, control screen, and hoses for supplying air to the system of the airplane. Charging takes place by transferring compressed air from a certain group of cylinders with a gradual build up of pressure to that required in the plane's system.



Charging with Compressed Air.

Cylinders of the VZ battery are charged with compressed air from airfield compressor stations which may be mounted on truck chassis or made in the form of a trailer. Compressor stations are also ground flight support facilities, however, they are not used for direct service of aircraft, but rather serve as a means of getting air compressed to the right pressure and to fill the airfield cylinders or VZ cylinder battery with it.

The most complicated and responsible matter in providing the airplane with gases is the charging of the plane's oxygen system with pure oxygen. Oxygen is necessary to sustain the life of the pilot at high altitude. At an altitude of 5,000 meters and higher, flights can be accomplished only in hermetically sealed cabins (passenger planes flying at altitudes up to 10,000 meters) or in cockpits equipped with devices which supply oxygen to the pilot (military aircraft).

Let us remember that oxygen systems used on modern military aircraft more often are charged with gaseous oxygen at 30 150 atmospheres and less often with liquid oxygen. The supply of oxygen in the airplane depends on the number of crew members and is calculated on the basis of established norms of breathing (6-7 liters per minute) while maintaining

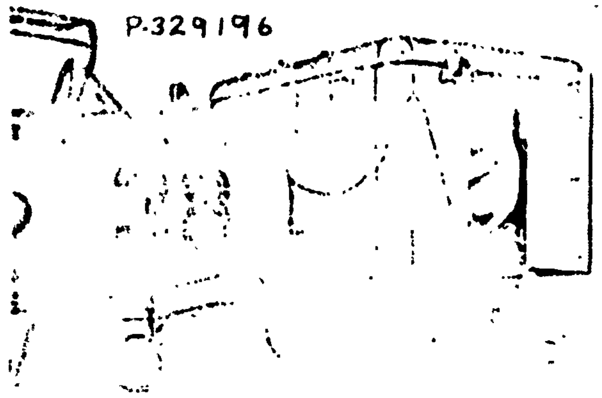
14—

a mandatory reserve. The higher the pressure in the cylinders of the oxygen system of the airplane, the lower that of the cylinders themselves. Thus, for example, a 7-8 liter cylinder is installed on a one-place fighter plane with an initial system pressure of 150 atmospheres. However, a significant increase in pressure in the system is undesirable.

The system using liquid oxygen has a fairly large reservoir which at the same time is the gas converter which transforms oxygen from liquid to gaseous state suitable for breathing. Therefore such systems are usually installed on bomber and military transport aircraft. The airplane's systems are charged with liquid oxygen from special transportable reserves installed on trucks or mounted on trailers (carts). The reservoirs vary in volume from 50-70 liters to 1,000-2,000 liters (1 liter of liquid oxygen produces 826 liters of gaseous oxygen upon evaporation). Either the same reservoirs or large-capacity reservoirs (tanks) are used at the airfields for storing liquid oxygen.

Liquified oxygen is a light-blue, portable liquid with a boiling point of -182.5°C. Under the effect of a large drop in temperature in relation to the surrounding air temperature, it boils constantly and evaporates through special reduction valves which are mandatory on all reservoirs and also in the system of the airplane. In order to charge the airplane's system, it is sufficient to raise the pressure in the transportable reservoir to 1.6-2.0 atmospheres, after which oxygen will begin to spill over into the system of the airplane by itself since the latter is at atmospheric.

Liquid oxygen constantly evaporates from the reservoirs in which it is stored at the airfield from the re-charging reservoirs even more actively in the process of recharging, and from the aircraft system themselves. This forces the specialists of airfield-technical support to keep a large reserve of liquid oxygen at the airfield and to re-charge the aircraft's system periodically even when the airplanes are not engaged in flying. It is estimated in figuring each charge that the oxygen supply should be more than twice the total capacity of the oxygen system of all the aircraft based at a given airfield. However, it must be borne in mind that the oxygen from the airplane's oxygen system (liquid and gaseous) is not completely expended (this is done to avoid impurities from entering the system). Thus, the unused reserve of liquid oxygen in the gas converter of the airplane's system comes to 10% of the amount in the reservoir while the residual pressure in the cylinders with gaseous oxygen should be in the order of 30 atmospheres with an initial pressure of 150 atmospheres.



Charging with Oxygen Using the AKZS.

The charging of the airplane's systems with gaseous oxygen is carried out using vehicular oxygen charging stations (AKZS). The operation of these stations is based on the principle of transferring compressed, gaseous oxygen from the large cylinders of the station to the smaller cylinders of the aircraft's system with subsequent pressurization of the system to the required amount using the compressors of the station.

The special equipment of the vehicular oxygen charging system (AKZS) consists of a battery of cylinders containing pure oxygen compressed to 150 atmospheres, and oxygen compressor driven by the truck's engine, a system for warming the lubrication of the compressor, a system for cooling and desiccating oxygen, control screen and electrical equipment.

The following operations can be carried out using the equipment of the station:

- charge the battery of cylinders of the station itself with oxygen to the necessary cylinder pressure (usually 150 atmospheres);

- charge the aircraft's cylinders (either on board or removed from the aircraft) to the necessary pressure (30 or 150 atmospheres);

- charge the parachute oxygen devices;

- transfer oxygen from one group of cylinders to another in order to obtain the necessary pressure in the group after partial consumption of the oxygen supply in the battery (of cylinders).

The oxygen used to charge the airplane's system should be clean without any impurities since it is intended for the breathing of the pilot on a one-place airplane or of all the members of the crew on a multi-place aircraft in flight. Poor quality (or as they say, low-grade) oxygen can lead to very serious consequences. In particular, oxygen must not contain moisture. That is why special devices are found on the AKZS, e.g., moisture separators and desiccators which remove oxygen from moisture in the process of charging the plane's system and also when filling the cylinders of the station itself. When working on the oxygen charging system it is necessary to be alert, accurate and to strictly observe special rules. This is made necessary not only by the great demands for oxygen being supplied to the airplane's system, but also by a number of specific properties of pure oxygen.

Pure (medicinal) oxygen explodes easily and is accompanied by fire. Of course, it is hard to imagine the kind of "specialist" who would permit the use of open flame or would light a cigarette while at the oxygen-charging station or charging the airplane's system with liquid oxygen from the transportable reservoir. But that isn't required. It is enough merely to forget that the clothes and hair of the person working with the oxygen apparatus may be saturated with pure oxygen and that it is precisely this oxygen which can ignite.

Pure oxygen has one more dangerous property. It ignites when it combines with fats (grease). To do this it is not necessary that grease must be poured into the oxygen or on the oxygen apparatus. For the oxygen to ignite it is only necessary that the hands are not carefully washed after working with this apparatus or that the instrument is not properly scoured.

A water-glycerin mixture is used for lubricating the oxygen compressor of the station because it is impossible to lubricate it with the ordinary lubricating materials. However, even when using water-glycerin mixtures it is necessary to observe certain rules. If the amount of glycerin in the mixture exceed 70% then the mixture may ignite by reacting with oxygen. A dangerous concentration of glycerin in the mixture is formed after a certain number of hours of operation of the station and for that reason it is necessary to check the concentration of glycerin. It is also necessary to check on the temperature of the mixture so as not to permit it to rise higher than 60°C. Otherwise it may also ignite.

Specialists who service the aircraft with pure oxygen should know its properties and observe a number of general operating rules when using any of the gas-charging assemblies which are used when charging with gases under high pressure. Thus, for example, the valves of the cylinders or charging hoses must never be turned off or on quickly and one must never stand facing the nozzles and hoses to avoid being struck by streams of gas moving under high pressure, etc.

Thus, highly qualified specialists who not only know their own stations and installations but also have knowledge of the physical properties of gases must work on the oxygen-charging and other gas-charging stations or installations.

Pure oxygen (liquid and gaseous) is obtained from special mobile stations or from factories. The great demand for oxygen for servicing military aviation makes it necessary to have highly productive mobile oxygen producing stations (factories) at each airfield or for a group of airfields (airfield complex). The production of oxygen in such stations (factories) is based on the liquification of atmospheric air and its separation to the basic constiguent parts (nitrogen and oxygen) under conditions of low temperature. Liquid nitrogen boils at a temperature of -195.8°C. Therefore, when evaporating liquid air the nitrogen evaporates from it first and the residual liquid is rich in oxygen. It is impossible to completely separate air into nitrogen and oxygen with only one evaporation and for that reason another multiple process of condensation of oxygen from the air vapors formed is utilized.

The separation of air into its constiguents parts is carried out in a special separating apparatus in which liquid oxygen is collected and nitrogen is ejected into the atmosphere. The process of extraction requires that the separating apparatus be in a quiet condition and set up in a strictly vertical position. Therefore the extracting station is only capable of working in a stationary condition. Since the process takes place at low temperatures, the apparatus of the station very quickly becomes covered with ice. When this happens, it is necessary to stop it, to thaw the ice which is covering the apparatus, to carry out preventive operations and to check the system. Thus the station (factory) works in so-called "batch operations", i.e., uninterruptedly for five or six days after which it is necessary to take a break. During the break period, the station can be relocated to another area. To carry out these "batch operations" it is necessary for the specialists of airfield-technical support to plan the utilization of the station, produce appropriate reserves of oxygen for the period when the station is idle and to correctly select the area where it is to be located for operations.

Now that we have looked at the procedure for charging the aircraft with fuel, special liquids and charges of gases, let us turn to one of the most important problems of support - providing means of destruction.

Supporting the Preparation of Armament

Airplanes are converted into a real military force only when they are armed. Until then they are utilized in military actions for carrying out reconnaissance, artillery fire correction and as a means of communication. The installation of armament permits military aircraft to be used for aerial combat with the enemy and for actions against land-based targets. It is necessary to note the great role played by many Russian pilots and designers in outfitting airplanes with armament and working out the basics for using this armament. Because they understood the unconditional need for armament on the military airplanes, they persistently sought a weapon for the airplane. Even though as early as 1912 work was carried out at the "Duks" factory in Moscow, on installing a machine gun on an airplane, and in October 1913 a successful firing on ground targets from an airplane was carried out at a firing range, Russian aviation did not carry armament at the beginning of the First World War. It was not until the end of 1914 that the French aircraft "Voisin" began to be armed, and one unit of them had machine guns.

In August 1914, the well-known Russian pilot P. N. Nesterov, who at that time was the Chief of the 11th Aviation Division of Russian Military Aviation, was the first in the history of aviation to use aerial ramming. As he was carrying on a flight on the "Moran" aircraft which was not armed, he attacked a small Austrian reconnaissance plane and knocked it down. The crew of the reconnaissance plane was killed, but so was P. N. Nesterov. The circumstances of his heroic death have been preserved in the file of the investigation. From this file it is clear how stubbornly this courageous man sought a means of combatting the enemy aircraft.

"3. The decision to knock down enemy aircraft was planted early in the mind of Staff Captain Nesterov. Thus, on the 5th and 6th of that very August in the town of Dubno he fastened a knife to the rear-end of the fuselage with which he proposed to cut the gas bag of the enemy blimp.

"During the period of his stay in Zlochev, he attempted to attach a long cable with a weight to the tail of his plane which he intended to use to entangle the propeller of the enemy airplane by flying at it head-on" (see the book "Istoriya Voenno-Vozdushnykh Sil Sovetskoy Armii", Voenizdat, p. 117, 1954).

In 1916 there was published in Russia a manual for the use of aviation in war (as a project) in which it already stated that the chief weapon of the airplane is the machine gun while on some aircraft cannons are used which are especially well suited for firing at balloons and ground targets. In addition, the manual pointed out: "Observer-pilots can take pistols and automatic weapons with them on the flight". And in fact, pistol and rifle duels between crews of the airplanes on both sides were often carried out in those years. The manual also said that bombs of different weight and types (fragmentation and high explosive) and inflammable substances are used for bombing from the airplanes, and also "strafing to destroy live targets".

In comparing the armament of aircraft of the period of the First World War with the armament of modern aircraft, it must be noted that the aircraft of our day continue to use the same forms of armament such as machine guns, cannons, bombs and inflammable substances, although, of course, they have undergone considerable qualitative changes. In the last decades other arms have been added to this such as rockets, special weapons of various types, and finally atomic weapons which first were dropped in the form of an aerial bomb on the Japanese city of Hiroshima and Nagasaki by the American imperialists. Besides atomic bombs, atomic war heads are now used in aviation rockets.

Specialists of engineering-aviation service carry out directly the preparation of the armament of the aircraft present at the airfield. In order to show the role of airfield-technical support specialists in this matter, let us group the armament of modern aircraft according to its basic forms and let us note that each of these forms is needed for arming in preparing the aircraft for regular combat flights.

By aircraft armament we understand the means of destruction along with the control and aiming devices. Modern airplanes have armament of the following types: heavy caliber armament, bombing armament, rocket and special armament.

Heavy caliber armament consists of heavy caliber aviation machine guns, cannons, gun sites and ordnance. On fighters and fighter-bombers (assault bombers) this armament is used for destroying aerial and ground targets and is concentrated in fixed installations which may be located in the front part of the fuselage, on the wing or in suspended containers. Heavy caliber armament is necessary on bombers to defend itself from enemy fighters. Here it is placed as a rule on a movable installation with remote control. Heavy caliber armament is also installed on helicopters and military transport planes.

Aircraft Weapons:
A. All weapons on the aircraft of the period of the First World War were handled "by hand": bombs - in the cockpit, machine guns - on a tripod above the pilot; the bombs were thrown overboard and the pilot-observer fired the machine gun. B. Armament of the fighter J-35 (Sweden): 1, wing fuel tank; 2, launcher with 19 free-flight 75-mm rockets; 3, guided missile "Sidewinder" (Rv-324) [Note: unknown]; 4, 500 kg aerial bombs; 5, 250 kg aerial bombs; 6, free-flight 135-mm rockets; 7, 80 kg aerial bombs; 8, 30 mm aircraft cannon; 9, launcher with 19 free-flight 75 mm rockets; 10, wing fuel tank; 11, guided missile "Sidewinder"; 12, belly fuel tank.

Cartridges are needed for heavy caliber armament. Shells of very different purposes are now used (armor-piercing, inflammable, multi-purpose, etc.). They are collected on ammunition belts made up of metallic links and in that form they are loaded into special ammunition boxes on the plane. Storing ammunition supplies in the airfield depots, charging them in clips and supplying them in this form to the airplanes is one of the jobs of the specialists of airfield-technical support.

It is necessary to add that the supply of ammunition on modern aircraft has somewhat decreased compared to the supply during the period of the Second World War because it had reached a maximum in the whole history of aviation. Thus, for example, the Soviet assault plane Il-10 had a total combat set of 1,950 rounds. But, probably, the most powerful heavy weapons armament was carried by the Tu-4 bomber (1946) - 11 cannons in five special turrets with a combat set of 4,850 rounds (1,060 kg). Even now the requirements for ammunition for the aircraft's heavy caliber armament is quite high. Recently multi-barreled cannons (6-8 barrels) having a very high rate of fire were quite widely used. The caliber of the cannons is usually 20-30 mm. Taking into account that the supply of ammunition for each cannon is 100-300 rounds and there are from 2 to 6 cannons (installations) on each aircraft, one can get a feel for the amount of work done by the specialists of airfield-technical support in preparing the ammunition.

The bombing armament comprises aerial bombs, bomb racks, control mechanisms (bomb release mechanisms), and bomb sites. Bombing equipment is now no longer installed only on bombers and fighter bombers, but also on fighters. Bombs on bombing planes are usually hung inside in the fuselage, while on other planes they are as a rule suspended under the wing.

The storing in depots and supplying to the airplanes of aerial bombs is part of the job of the specialists of airfield-technical support. While the requirements for bombs for fighters and fighter bombers is relatively low, the number of bombs used in supplying bombers is enormous. Thus, front (tactical) bombers take up to 3,000 kg of bombs, and long-range (strategic) bombers up to 20,000 kg and more. The B-52 bomber used by the Americans in Vietnam can carry 66 bombs weighing 340 kg each or 108 bombs of various caliber having a total weight of 27,000 kg.

Providing aircraft with aerial bombs has become considerably more complicated because these bombs have become exceedingly varied both as to type and caliber. Depending on what kind of targets the bombers are after, bombs weighing from 2 to 3 kg (anti-tank or incendiary) may be

used in magazines up to several tons (high-explosive or high-explosive fragmentations). In addition, bombs of medium caliber (100-500 kg) may be used for special targets of high-explosive, illuminating, smoke-generator and other operations.

Since it is not known earlier exactly what bombs will be required by the aviation units, the airport must have a supply of practically all bombs or a majority of types and calibers. However it is necessary to take into consideration that the probability of using bombs of different caliber and type is not the same. A determination of this probability is one of the most important jobs of the specialists of airfield-technical support at that time when the question is being decided how many and what kinds of bombs should be kept at the airfield.

Bombs are supplied to the airplanes on trucks or on special bomb carts which are towed by tractors, depending upon the caliber and type. To load and unload bombs, especially bombs of higher calibers, lifting cranes and automatic loaders are used. Hanging bombs on airplanes is carried out using special equipments (cranes and hoists) which are located on the plane or in the inventory of the ground equipment for this purpose.

Bombs of one and the same type can be armed with different fuses (timed fuses, contact fuses, etc.). Fuses are stored separated from bombs and are supplied to the airplanes at the direction of specialists of the engineering-aviation service.

The missile armament of the aircraft consists of missiles, aiming systems, launching and guidance of missiles. Missiles designed for destruction of air and ground (sea) target are subdivided into classes depending upon the purpose: "air-air" and "air-ground".

In addition, they are divided into free-flight missiles (NUR) and guided missiles (UR). Directing the free-flight missiles to the target is carried out by the launching device of the airplane (attitude of the aircraft) while the guided missile works automatically with the help of special guidance systems.

Small caliber missiles (50-70 mm) are used on fighters and fighter bombers and are usually located in multi-barreled installations, which permits placing a large number of such missiles on board the aircraft. Missiles of larger calibers are located on the airplane under the wing, in the fuselage or under the fuselage. Large-caliber guided missiles are used on bombers. They are subdivided into guided aviation bombs (torpedoes) and guided aviation crews missiles of various range.

A different number of missiles is required for different aircraft. Thus, for example, the US tactical fighter (i.e., fighter-bomber) F-105B "Thunderchief" has up to 167 free-flight 70-mm missiles and 2-4 guided missiles in its combat armament. The B-57 tactical bomber can carry eight 127-mm guided missiles, while the B-52 strategic bomber can carry up to four guided missiles weighing 4 tons, each with a nuclear war head. Guided missiles for combat use are usually prepared by specialists of the engineering-aviation service. Specialists of the airfield-technical support store missiles at depots and bring them to places (positions) of preparation. Supplying of free-flight missiles is carried out in exactly the same way as supplying the aircraft with bombs.

The special armament of the aircraft consists of equipment for utilizing inflammable liquids, means of causing interference to the radio-technical devices of the enemy (for example, dipole reflectors), etc. Supplying these types of equipments is accomplished in the same way as the supplying of ammunition, bombs and free-flight missiles.

In supporting the flight preparations of the airplane in general and the armament in particular, specialists of airfield-technical support accomplish two basic tasks: first, they accumulate and maintain at the airfield stores of ammunition, bombs, bomb fuses, missiles, inflammable liquids and tanks for them, jammers and several others; secondly they supply (bring up) all these items to the airplanes or to places especially set up for transferring two specialists of the engineering-aviation service who put them directly on the airplanes.

In a number of cases, specialists of the airfield-technical support prepare means of destruction to be placed on the planes in a certain volume. Thus, for example, ammunition is taken out of storage and is loaded in belts in the relationship established according to types of shells (incendiary, armor-piercing, etc.) in each belt. It must be said that this is not one of the easy jobs. It is necessary to work with a large amount of ammunition of fairly high caliber. Special machines which connect shells to one another with metal links are used in making up ammunition belts. Aerial bombs, missiles and special devices also require a certain preparation. In each concrete case depending on type, shape and caliber of the bomb, missile or special device, the specialists of airfield-technical support determine the extent and character for ample preparation of these items at depots so as to reduce to a minimum the amount of time expended on the installation of these items on the airplanes.

If it is taken into consideration that the means of destruction are used during the course of combat operations on each flight and, as a

rule, are completely consumed (with the exception of ammunition) and also the fact that in modern combat airplanes the various means of destruction are usually used simultaneously, then it will be understood what an enormous amount of work must be performed in the organization and provision of the airfield-technical support to modern combat aviation with all the means of destruction. During the course of combat operations, specialists of the airfield-technical support must maintain reserves of the means of destruction at airfields in the necessary amounts not only so far as quantity but also so far as nomenclature is concerned. When the access to airfields is made difficult owing to the remoteness of the supply base, enemy actions, condition of roads and fords, camouflage requirements and other conditions of the front (tactical) situation, it becomes extremely complicated to maintain reserves of the means of destruction at airfields at the required levels. Many personnel and resources of the aviation rear take part in accomplishing this task.

Starting the Engines and Towing the Aircraft

"The Airfield." It is completely dark. We remove the coverings by feel. Saninskiy (squadron technician, my note - V. B.) has just succeeded in turning over the automatic starter and turning on the hot water through the water hose. We try to start the motors. But compressed air only spins the propellers. There is not a single flash, and the motors have grown cold.

"Open the radiators, let out the water!", Saninskiy commands.

In the darkness we feel for the drain cocks. They are covered with a thin sheet of ice. We open them with difficulty. We still have to open the top plug on the water tank.

The water hose is brought up. Streams of hot water caught by the wind pour over our hands, splash in our faces, and wet our clothing. Nina Shebanina (airplane technician, my note - V. B.) lies under the radiator and tests the water - it is necessary to keep pouring until hot water comes through. A large puddle develops underneath the airplane. Soaked to the skin, Nina commands, "More, still more - now its hot!"

One wet hand is frozen to the blade of the propeller on which it is hanging and a second hand aches from the pressure of holding the nozzle of the water hose open.

We switch on the automatic starter. The propeller spins with a whistling noise and now you can no longer see its individual flashing blades. A flash, another flash and then exhaust noises similar to

shots - and then the once dead motor begins to work. We sit on the tail so that the plane does not go over on the propeller at high rpm. A stream of air from the roaring motor is added to the icy wind. It pushes us against the tail, tears at our clothing and pierces to the core. Immediately it becomes unbearably cold, our faces become numb. We are covered with a white sheet of ice"[1].

As we pay our respects to the selflessness of the work of the mechanic and technician as they perform in this episode the engineering-aviation service, we note the modest participation also of specialists of the airfield-technical support which was at that time a part of the battalions of airfield servicing (BAO). They were the chief of the water and oil servicing (VMZ) who saw to supplying the airplane with hot water, and the chief of the automatic starter (AS) who started the liquid-cooled engine of the Yak-1 airplane.

In our day, liquid-cooled engines are not longer used for military airplanes. Nevertheless, even modern airplanes need water. In particular, it is injected into the jet engine for a short-term increase (forcing) of its thrust. For example, the B-52 airplane (USA) has tanks for water with a volume of about 1,C00 liters. The water is completely consumed when the airplane takes off with a complete flying load (more than 180 tons).

Starting the aircraft engines in the period of the Second World War took place with the help of compressed air which was forced into a special starting system on the plane, or with the help of a mechanical starter which was mounted on a truck. Some airplanes used electric and inertia starters.

Electric starters, starter generators and gas turbine starters mounted directly on the aircraft are now widely used for accelerating the rotor when starting turbo-jet engines. This assists independent starting, i.e., independent of ground sources of power. However as a rule, independent starting is only resorted to in those cases when it is impossible to use ground sources of power or when it is necessary to start the engine as fast as possible. In the majority of cases ground sources of power are used for starting engines as a means of economizing on the on-board sources of power. Electrical assemblies, carts, air and rotor starters which are available to the specialists of airfield-technical support are used as ground sources.

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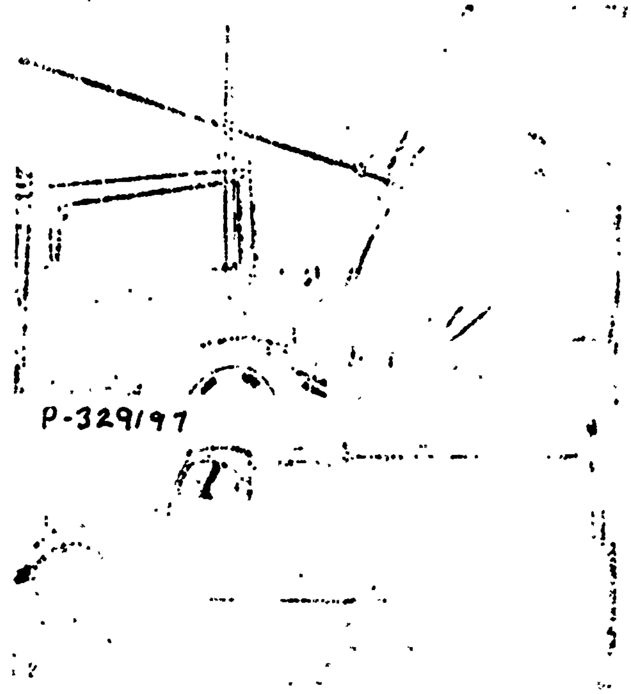
[1]See the book "In the Air at the Front", memoirs of Sophia Osipova, Izdat "Molodaya Gvardiya", pp. 233-234, 1962.



Starting the Airplane Motor:
1, mechanical starter in the period of the Great Fatherland War; 2, airfield electrical system at the present time.

At the present time, the electrical starting method for starting engines is most widespread when the electric starters are installed on board the airplane. When starting the engine at the airfield under normal conditions, the power supply for the starters is furnished from the APA. This is a fairly complicated process, the character of which is partly defined by the starting program. Thus, for example, starting systems which switch in voltages from the power supply circuit in the processes starting or which increase the current in steps while maintaining a strictly defined level of current. In these systems, a starting panel which provides for the change in voltage is set up either on the aircraft or in the ground electrical sub-system.

We note that it is not always suitable to install the panel on the APA since the APA with the starting panel installed on it may not always fit into the starting program for aircraft of any particular type and this would limit the possibilities of its application, and consequently,

the possibilities of all-around airfield-technical support of flights at a given airfield. The possibility of supporting all types of aircraft at any airfield depends on the presence of different types of material resources at the airfields.

Here is a simple example. An airfield has supplies of gaseous pure oxygen and the means to charge the aircraft systems, but there are no supplies of liquid oxygen or the charging equipment for it. Airplanes having a liquid oxygen system can never land at such an airfield. In addition, it would be uneconomical, burdensome, and expensive to always have supplies of liquid oxygen at each airfield against the case that sometimes airplanes having such a system would land there since liquid oxygen, as is well known, constantly evaporates.

How is it then possible under such circumstances to provide all the material resources to all airplanes? There are several ways. Supplies of all material resources may be gathered and maintained at all airfields. Of course, this way is not the easiest and not only from the point of view of economics (which is some importance even in military matters), but also from the point of view of the mobility of support personnel and resources. Overburdened with large supplies of material resources, the units carrying out airfield-technical support will lose the mobility which is so necessary for the support of aviation.

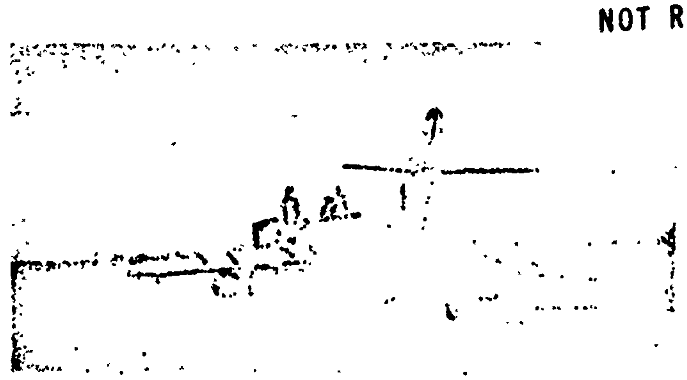
It is more feasible to maintain material supplies which are systematically consumed and to requisition quickly from supply bases those resources which are only required from time to time. In other words, it is necessary to maneuver support personnel and resources. The ability to maneuver personnel and resources is a necessary quality and requirement for leaders and organizers of airfield-technical support. Among these, the ability to predict possible requirements, foresee the places where they will arise, and predict the levels and times involved is especially valuable. Leaders and organizers of airfield-technical support can do this only on the basis of continuous study and analysis of the supply situation and the decisions and plans of aviation commanders.

Turning once again to the above-mentioned episode of starting the motors, we notice one thing. In testing the engine after it began working, the mechanic and technician "sat down on the tail" so that the airplane "would not stand on its propeller". The figure of the mechanic on the tail of the airplane blown by the powerful air-stream from the propeller of the airplane was a typical phenomenon of that period of the history of aviation.

Today airplanes, as a rule, have landing gear with a nose wheel which

prevents the possibility of the airplane "standing on its nose" when testing the motors. However, another difficulty has appeared. The engines of modern military aircraft have such a great thrust that when turning them at high rpm, the airplane begins to move along the ground even though it is restrained with brakes and chocks under the wheels. Fighter planes which have a relatively light weight and tremendously powerful engines move away especially easily. In order to test the engines, the airplane must be securely tied down on a special testing [gazovochnoi] platform equipped with mooring attachments and screens for diverting the stream of gas from the surface of the platform. This has made it necessary to have prime movers to tow the airplanes to these platforms.

The necessity of moving the airplane along the ground with engines off appeared along with the first plane. At first such moving was carried out by people, and then by various prime movers. During the period of the Second World War, towing at military airfields was seldom done, and then only in cases where independent taxiing of the airplanes themselves was made difficult by the condition of the ground on the landing field of the airfield.



Towing the Airplane.

Towing became quite widespread with the appearance of jet aircraft. The basic reason for this was the large fuel consumption of jet aircraft and the relatively short time the engines could be operated before overhaul (in the first period). Gradually the effect of the second reason significantly declined since the time before overhaul of engines was brought up to acceptable norms. However, the consumption of fuel remains large - this is an organic property of jet engines - and therefore the towing of aircraft at the airfield is now used in many cases to economize on fuel. In peacetime, economy is gained also with respect to the operating time before overhaul of the engines by means of towing.

In addition, the towing of aircraft increases the safety of movement on the airfield when there are massive flights, when the earth on the landing field and on the taxi strips is not of sufficient hardness or in case of ice formations. Unserviceable planes are towed to the repair shops located at the airfield, to the refueling stands of the TsZ and to the aviation range for pre-firing of weapons, etc.

Prime movers provide for the towing of airplanes. They have become one of the most numerous resources of ground flight support. In most cases, the prime mover is a truck. During the towing, the airplane is connected to the prime mover with a special towing device. Other kinds of prime movers are also used such as tracked and wheeled vehicles. Thus, for example, there are prime movers which tow the airplane by the nose wheel and other prime movers on which the nose wheel of the airplane is mounted.

Towing the airplane with a prime mover is a complicated business requiring a great deal of attention and know-how. It must be carried out smoothly without jerks at a low rate of speed and in such a way as to avoid damaging the airplane. At the same time, all the operations of fastening the airplane to the prime mover, unfastening it and the towing of the airplane itself must take place fairly quickly and with dexterity at military airfields because otherwise the preparation of the airplane for regular flight would be held up or perhaps the take-off to carry out a combat mission. For this reason a thorough special preparation is required of the drivers of prime movers.

This is the substance of the airfield-technical support to aircraft flight. Specialists of airfield-technical support participate in checking the condition of the aircraft's systems and satisfying the concrete needs for material resources, provide for refueling the aircraft's systems and recharging with gases, provide for the preparation of armament, towing the aircraft and starting its motors. In doing this, a variety of airfield-technical support resources are used on which highly qualified specialists work.

Flight Support and Its Safety

What is Flight Safety?

A magazine is published in the USA which is called "Aerospace Safety" [*Aviatsionno-kosmicheskaya bezopasnost'*]. This is an organ of the special aerospace safety service which has representatives (officers) at all aviation units. Why was such a service created and what are its missions? So far as the first question is concerned the following statement of one of the leaders of the service, General Stuart quoted in the April number of the magazine "Aerospace Safety" for 1966 answers this question to a certain extent:

"At the present time, the United States Air Force has every year about 300 serious incidents in the air and a large number of accidents on the ground".

It may be assumed that the word serious in the given context means flying accidents which have caused the loss of aircraft and in many cases even the death of fliers or whole crews. And that is all during training flights since there is no doubt here that the losses of aircraft and flying personnel during combat operations and, in particular, during the plundering air raids on the Democratic Republic of Vietnam or the actions against the patriots of South Vietnam are not taken into consideration.

And thus it is the occurrence of flying accidents, the death of flying personnel on whose training years are spent and the losses of aircraft, each of which costs millions of dollars and sometimes tens of millions of dollars, which is the basic reason for the creation of this special safety service. A flight safety service at the present time is found in the aviation of the majority of developed countries of the world. The question may arise: were there really no flying accidents with the loss of aircraft and death of people earlier or is the condition of modern aviation engineering worse than it was earlier?

Of course, there were flying accidents earlier and the aviation engineering was worse in reliability and quality than it is now. There were not fewer flying accidents in percentage of the number of airplanes, but rather more than in our own day. However, at the present time the consequences of every accident are immeasurably more serious than, for example, before aviation was equipped with jet aircraft. These accidents are connected with very serious moral and material losses. The high level of the development of aviation engineering, its complexity, the saturation with a large number of systems and equipment, the high speeds and altitudes of flight, the tremendous demands on airfields, on the

state of material resources consumed in flight, the extremely high demand in flight on the body and mind of the aviator - all of this and more creates a much higher potential for flying accidents than the flights on light, slow-moving airplanes at low altitude and only flying in favorable weather.

What are the missions of the safety service? It is not difficult to answer this question: to increase flight safety. Here is another matter to answer the question as to how flight safety can be increased. The trouble is that this very same service, no matter how many specialists it has, is not able to radically resolve the task of increasing flight safety.

When does the danger of flying accidents or accidents on the ground connected with the use of aviation equipment arise? Probably when something is done contrary to the way it was suppose to have been done as it is necessary to have done it, i.e., incorrectly. In order to clarify this situation let us turn to an example not connected with flying. Imagine yourself at the intersection of a city street, the traffic of which is regulated by a traffic signal. What causes the danger to the pedestrian going across the intersection? There are several reasons for the danger arising. The pedestrian crosses the intersection against the red light; the driver of a motor vehicle failed to observe the rules of driving and crossed the intersection against the red light; the traffic signal has broken down, traffic is not regulated, pedestrians and drivers act "at their own risk". Are those all? No. Each of the reasons mentioned can be analyzed and there will appear several "primary" reasons which caused them. For example, why did the pedestrian cross the intersection against the red light? Either he does not know the rules for pedestrians or he was lost in thought and did not pay attention to the traffic light, etc., etc.

In the above example, one more question should interest us from the point of view of safety. Who is responsible for creating the danger? Several people: the pedestrian; the driver of the motor vehicle; the person responsible for the condition of the traffic light. Who is responsible for the pedestrian not knowing the rule or for the driver not knowing the rules, etc.

But let us return to flying. Flight danger depends on a great many factors both directly connected and not connected with the conduct of flights. Here are some of these: the level of preparation (training) of the flying personnel; the reliability of aviation equipment; the discipline and responsibility of the personnel; the organization of flight and their servicing, etc. It may be pointed out that once factors are

known on which safety depends then there is an increase in safety; it is a simple matter. It is necessary to maintain each factor, for example, the training level of the flying personnel, at the required level. However, the matter is far more complicated than it seems. First, maintaining each factor at the required level is a complicated matter in itself requiring the daily, persistent work of everyone connected with it and not only commanders and chiefs. Secondly, with the general, excellent condition or level of these factors, it is possible to have individual deviations for very different reasons. And there are other difficulties.

From what is said it follows that in the work of providing for an increasing flight safety, everyone who has any kind of relationship to it should participate. Of course, commanders and chiefs should head this work, but everyone should participate and work for it. One of the most important conditions for the success of this work is establishing the reasons for those deviations from the norm, those deficiencies which are found in the condition or level of each of the factors which effect flight safety.

Let us now turn to the missions of the flight safety service. One of these is keeping track of accidents. A more important job is to remove those reasons which lead to the occurrence of accidents and the working out of concrete measures which would permit these reasons to be eliminated. Of course, these jobs are also part of the responsibility of commanders and chiefs, but the service should assist them in their work, and that is what the service has been created for.

In the theory of flight safety there is a concept of the accident premise. By the word premise we understand the concrete potential possibility for accidents which arises as a result of improper actions but which has not lead to an accident because of other reasons (the improper actions have been detected and simultaneously improved, skillful actions on the part of the personnel in a dangerous situation, etc.). In other words, the premise for an accident differs from an accident itself only by the fortunate outcome.

The struggle with accident premises is a most important responsibility and duty of the entire aviation personnel. It is the responsibility of specialists of the flight safety service to consider accident premises, analyze them and work out on this basis concrete recommendations to provide for safety. Once again we should emphasize the necessity for concrete recommendations and not just general slogans and diffuse appeals such as "Firm Up", "Service", "Increase", etc.

Having armed ourselves with some general concepts and information

from the theory of flight safety, let us now try to find out what affects airfield-technical support and what the organization and provision of this support has on flight safety. Flights are carried out at an airfield whose condition is the responsibility of specialists for airfield-technical support. In preparing the aircraft for flight, specialists of airfield support also take part, and in so doing they use various technical and material resources. Specialists of airfield-technical support participate in providing food for the flying and ground personnel, their relaxation, and in solving a number of other problems having a greater or smaller relationship to flight and consequently, to their safety. It is natural therefore that to a large degree flight safety depends upon the quality of the work of these specialists, their discipline and responsibility, their ability to work correctly and without waste.

It is not always easy to follow the relationship between flight safety and the actions or quality of the work of specialists of the airfield-technical support. Here is one of a number of examples. Fliers come from the living quarters to the airfield to participate in aircraft flight. On the way, the bus stops because of a malfunction for which the specialists of the automotive branch are responsible, and they are stopped there 30 to 40 minutes. Can this incident then affect flight safety? Yes, maybe. The delay on the road led to the fliers being late. They tried to make up the lost time and, acting hurriedly, they made mistakes in the flight preparations. These mistakes did not lead to an accident, but they were premises for one and hence did not prevent the possibility of an accident.

In the example cited, the relationship is fairly complex, but it is there. From this it follows that there is a necessity for accurate, correct and timely actions of all specialists of the airfield-technical support in accomplishing absolutely all tasks connected with flight safety. However, there are other more important fields of activity of specialists of airfield-technical support in which deviations from established rules, norms and procedures directly affect flight safety. Such fields are:

- preparing the airfield for flight;

- supporting the preparation of the flying personnel for flight;

- the total organization of airfield-technical support of flight.

The activity of specialists of airfield-technical support in each of these fields is an accumulation from certain jobs and measures,

procedures for the accomplishment of which are regulated by operating rules, instructions and manuals. Even deviation from established rules and failure to observe requirements of regulatory documents lead to the creation of premises for flying accidents or even worse, to flying accidents themselves and, consequently, reduce flight safety.

Mention was made earlier of individual kinds of operations for supporting the preparation of airplanes for flight. Mention was also made of several rules for carrying out these operations (for example on refueling and on charging with oxygen), of requirements for material resources, of technical resources used and of rules for their use. All this has a direct relationship to providing flight safety in the period of support to the preparations for aircraft flight. Let us now familiarize ourselves with the measures for providing flight safety during the preparation of the airfield for flight, in preparation of the flying personnel for flight, and also in the total organization of the airfield-technical support of flight.

The Airfield Is Prepared for Flight.

The passenger "using the services of Aeroflot" usually flies in good weather and comes to the airfield when the airfield is ready for flight. If the weather is not favorable and it is not good flying weather, Aeroflot changes the flight times. Military aviation is geared for the conduct of combat operations and therefore is frequently forced to fly in such weather which according to the norms of Aeroflot is unconditionally not good enough for flying. In a number of countries the aircraft designation "all weather fighter" is even used. The continual improvement in aviation technology, navigational and pilotage equipment of the aircraft and the equipment of ground support to airplane navigation has steadily widened the possibilities for flying military aircraft under difficult weather conditions.

The basic demand made of the military airfield is to be constantly ready to service flights. The readiness of the airfield is defined by the readiness of its constituent parts - runway (VPP), taxi strips (RD) and parking places for aircraft (MS) - and the whole landing field. The control points and radio-technical and light-signal facilities located at the airport must be ready to control and service flights. The numerous specialists of the ground support services and the various technical facilities at the airport must also be in a condition of readiness for flight support. Finally, to service flights at the airfield there must be supplies of material resources; fuel, ammunition, compressed air and many other things which will be discussed later. However, the basic element of the airfield is the landing field and the preparation of it

for flying is the most important task of airfield-technical support. And for this reason we begin our story about the preparation of the airfield with a story about the preparation of the flying field.

At the outset let us agree on the meaning of the concept "preparation of the landing field" itself. In special literature, the expressions "preparation of the landing field" and "preparation of the airfield" are often used in the sense of their construction, construction of a new airfield (landing field). In this book, we speak of preparing for flight a landing field already constructed (constructed earlier) of an airfield on which aircraft are based and flight is carried out.

It might be indicated that the preparation for flight of a landing field on an operating airfield is not a difficult matter and does not deserve the special attention. This is far from the fact. The work in the preparation of a flying field is laborous. There are a number of reasons for this. Here are the chief ones.

With intensive use of a landing field by airplanes, the turf covering the earth part is damaged, ruts are formed from the wheels of the landing gear, dusty sectors and slight unevenness appears, individual sectors and elements of the artificial surfaces of the runways, taxi strips and parking places are damaged, especially surfaces made of prefabricated, sectionalized elements, seams between concrete surfaces and the connectors between elements of the prefabricated surfaces are destroyed, and the base under the prefabricated sectionalized surface is damaged.

Mechanical destruction of the natural (earthern) and artificial surface of the landing field in many cases in intensified by the action of unfavorable climatic conditions and inclimate weather of the area in which the airfield is located. In rainy periods the toughness of the earth is greatly reduced even of very fine grass covering. Flooded areas, deep ruts, pools, etc., appear on the landing field. A landing field which does not have a covering of turf has much dust in dry weather.

Snow is especially troublesome in regions having abundent snowfall in the winter, and ice formation is a nuisance in the periods of inconstant temperatures in the spring and fall. The necessity arises of removing or packing the snow on the landing field and removing the film of ice on the artificial surface. As a result of the fluctuation of temperature and the thawing and freezing of water connected with it, the seams of concrete surfaces and the edges and corners of concrete slabs of such surfaces on permanent airfields are destroyed

There are very high requirements for the cleaniness of the surface of the runway, taxi strips and parking places. On the surface of these parts of the landing field there must be no objects which could be sucked into the low-slung air scoops of modern jet aircraft motors. This could lead to a breakdown of the engine. The force of the stream of air sucked in by the jet engine is such that it is dangerous for a person located several meters from the air intake device. Foreign objects on the landing field (metal parts, concrete fragments, etc.) can damage the tires of the airplane's wheels during the acceleration or deceleration run, which can also lead to an accident or catastrophe. If you consider that military aviation, especially during wartime, must carry on flights under any conditions and at a very high intensity; then the importance and complexity of the preparation of the landing field of the airfield for flight is apparent. When the landing field is prepared for flight it should not only guarantee the potential possibility of take off and landing of airplanes, but also it should guarantee flight safety. In other words, the possibility of flying accidents caused by reasons connected with the condition of the landing field (runways, taxi strips and parking places) should be eliminated.

The system of measures for flight preparation providing for a continuous preparedness of the landing field (this may be considered practically international) includes the following: rational use of the landing field, systematic check of its condition, and maintenance and repair of the landing field.

Let us remember that temporary military airfields may have a completely earthern landing field (runway) or one partly covered with a synthetic surface (on the take-off and landing strip, taxi strips and parking places). It is mandatory to have a synthetic surface on the VPP, RD and MS at permanent airfields. Therefore, it is necessary to carry out the preparation for use, control, maintenance and repair of the landing field both on the earthern part and on the parts having various synthetic surfaces at temporary as well as at permanent airfields. For this reason we shall acquaint ourselves at first with the measures carried out on the earthern part of the landing field and then on the synthetic surfaces. We will look at the preparation of the flying field during wintertime separately.

The Preparation of the Earthern Part of the Landing Field. Rational use of the earthern landing field (runway) has the aim of preserving for as long as possible the surface from damage from the wheels of the aircraft's landing gear and various technical facilities used in servicing aircraft at the airfield and in accomplishing work at the airfield itself.

At airfields having a take off and landing strip (VPP) with synthetic surface, flights from the earthern runway are usually only carried out when the condition (toughness) of the earth excludes any serious damage by the wheels of the airplane's landing gear. When using the earthern part of the landing field the paths for acceleration and deceleration run are periodically changed, designating corresponding trips for take off and landing; the pressure in the tires of the wheels is reduced (if this is permissible); a schedule for moving technical facilities on the airfield is established which will exclude movement over the operating part of the landing field: when it is necessary to use tracked vehicles, the tracks are equipped with wooden or rubber inserts (coverings). In addition, in order to maintain the turf cover in good condition it is necessary to care for the turf, to fertilize the grass with mineral fertilizers, to mow it periodically, water it in the dry period of the year, combat rodents, and periodically change the strip areas used for take off and landing, etc. It may seem old fashioned, but airfield-maintenance sections which in our day have the job of maintaining the earthern landing fields at military airfields should have such prosaic mechanisms as mowers, rakes, and harrows. Of course, the mowers, rakes and harrows are now used primarily with tractors but the use of horses is not excluded. These sections take care of mineral fertilizers, grass seeds and other things, which are far from the swift, modern airplane.

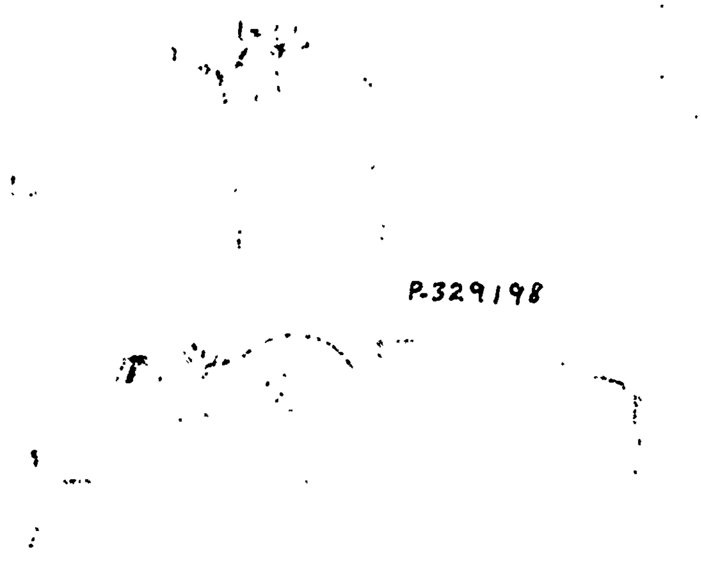
One of the basic measures in caring for the earthen landing field is the systematic packing of the earth on the VPP, RD and MS to increase its loading capability and decrease the penetration of water. In the process of rolling the earth, small ruts made by the wheels of airplanes are also removed. Road rollers on pneumatic tires with various pressure which can be regulated when necessary are chiefly used for rolling.

Increasing the carrying capacity of the soil and earth is achieved by reducing moisture and increasing its agricultural properties through the use of drainage techniques. For these purposes, we find the practice of leveling (leveling and contouring) the surface of the landing field, packing it, the building of ditches, furrows, earthen gutters, and dykes to catch water at the approaches to the landing field.

Complicated systems of drains and gutters with facilities for collecting and diverting surface and ground water, including deep drainage, are constructed at permanent airfields.

In a number of cases (for example, in arid regions, on sand, forest soil and takyr) a covering of turf is absent on the earthen part of the landing field and it is practically impossible to create one. In a period of abundent rainfall, the landing field becomes quickly soaked

and unusable. In the hot and dry period of the year, the scourge of such airfields is dust. In order to maintain earthen landing fields in normal condition without a covering of turf, a systematic leveling of the surface (removal of ruts and rolling of the surface) is carried out systematically and various methods are used to reduce dust (systematically watering the intensively used portions of the landing field with water and strengthening the surface of the earth with bonding materials - asphalt or petroleum - or the earth stabilizes by settling.



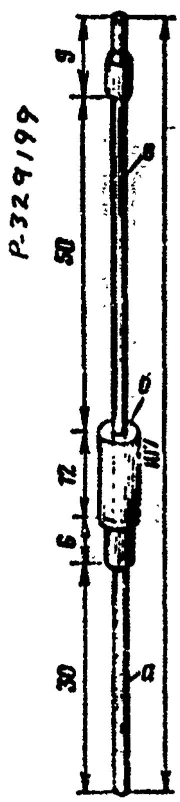
Packing the Earth on the Flying Field:
1, in the period of the First World War;
2, at the present day (self-propelled road roller on pneumatic tires).

Creating a good covering of turf and maintaining it, packing the surface of the landing field, providing for gutters and drainage and settling of the earth - all of this permits utilization of earthen airfields for basing modern aircraft of practically all types.

In order to determine the suitability of the earthen landing field

for flight (for toughness and flatness of the surface) a check of its condition is carried out. It must be said that this task is not one of the easiest. It is necessary to check a very large area in a short time.

"In the good old days" aviation commanders applied such methods as "testing with the heel" for toughness and "testing by eye" for evenness. Then another method found wide application. The commander seated himself in a motor vehicle, usually an automobile, more rarely a truck, and at the maximum speed for the vehicle he raced along the runway in the directions designated for take off and landing of airplanes. The character of the ruts (their depth) was an indicator of the toughness of the earth and the presence or absence of strong bounces of the vehicle (bumbs) during such "races" was a measure of the flatness.



Plunger for Checking the Toughness of the Earth:
a, pin which is sunk in the ground; b, movable weight; c, directing rod.

This method is often used even today. However, the high demands for toughness and levelness of the surface of the flying field for modern aircraft has made it necessary to convert to more exact methods of checking. One of these, for example, is checking the toughness of the earth with the help of a special mechanical device - the plunger. The landing field is conditionally broken down into squares at the corners of which and at all doubtful places, a test is carried out on the earth for toughness: the movable weight strikes the plunger with the same force until its pin has reach a certain depth, the number of blows is calculated, and then from a table or graph the toughness of the earth is calculated taking its type into account (sandy, sandy loam, argillaceous, etc.).

The levelness of the surface is checked simultaneously with a check of the toughness. If necessary, a selected leveling of different paths is carried out. At the same time a check is made of the toughness and levelness of the surface and the cleaniness of the landing field, i.e., the absence on it of objects which could fall into the engine or damage the pneumatic tires.

Laying a Synthetic Surface on the VPP, RD and MS. A synthetic surface facilitates the general preparation of the landing field for flight, of course, provided it is properly used during the flight time, systematically checked, maintained and repaired. The type of surface is very important. First-class surfaces are subject to less damage but they are more complicated to repair. Temporary and especially prefabricated sectionalized surfaces require more careful maintenance and are more subject to damage in the process of use, and also as a result of the effects of weather and climatic conditions.

Measures to prevent damage to the synthetic surface by high-temperature streams of gas from the airplane's jet engines have been adopted for the utilization of the landing field. During engine tests, this stream is deflected from the synthetic surface of the platform by means of special screens. The movement of heavy technical facilities of ground support over an insufficiently hard surface is limited. The basic measure in maintaining the landing field in good condition is checking on the synthetic surfaces and their repair.

Checking the condition of the synthetic surfaces is done by visual observation. Effective places or sections of the surface in need of repair are noted in the checking process. Each type of surface is subject to specific damage. Edges of the slabs and temperature seams are damaged on concrete surfaces, and sagging of individual slabs and damage to the joints of the slabs appears as a result of destruction

by water of the synthetic base of the surface. Undulations and buckling, cracks and breaking up of small areas of the surface (so-called pits) occur on the surface of asphalt-concrete surfaces.

The pre-flight check of prefabricated, sectionalized surfaces made of metal sections must be checked with special care. Numerous areas of damage and irregularity appear on such surfaces as a result of use and from the effect of atmospheric precipitation or ground water. The connections between sections are damaged and some sections or parts are bent. At individual sections of the synthetic base, the earth on which the surface is laid is washed or blown away and the surface settles and breaks through. The attachment of the lateral and end sections of the surface to the foundation (earth) is damaged. Sometimes parts of the linkage (car pins and clamps) fall out of the surface. These parts are extremely dangerous for aircrafts taking off or landing.

Systematic maintenance of the synthetic surface, which should take place with the preparation of the airfield for flight, includes removing dust, sand and dirt from the synthetic surfaces, removal of foreign objects (pieces of concrete, stones, parts for reinforcement of metal sections, etc.), and, where necessary, hosing down and washing the surface, replacing reinforcements to metal sections or straightening them, and other work. The basic jobs in the maintenance of synthetic surfaces have been sufficiently well mechanized. Hosing and washing machines with brushes are widely used. Such machines are used to clean streets and roads and are well known to many readers. In recent years, special airfield vacuum cleaner machines have begun to be used. But the requirement for careful cleaning of the surface makes it often necessary to use manual labor even now when we have a variety of machines.

Repair of the surface, more precisely its continual repair, consists in correcting the defects and damages noted in the course of inspection. The repair methods depend upon the character of the defect or damage and the type of surface.

On concrete surfaces it is most often necessary to repair the surface and the edges and corners of a slab, clean out seams, and replace them with special cement filler between the slabs, replace individual slabs and also the foundation under the surface. On asphalt-concrete surfaces, undulations and buckling of the surface are repaired by leveling the defective places with the help of special tamping machines. Sections are first heated. Metal surfaces are prepared by leveling individual sections (by removing them from the surface or by leaving them in), or individual sections are replaced, while the foundation under the sections of the surface are repaired by filling in and tamping down the earth or stones while at the same time a preliminary analysis of the section of the surface is carried out.

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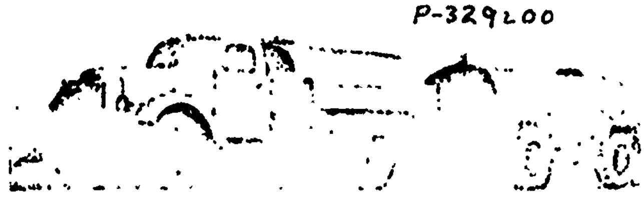

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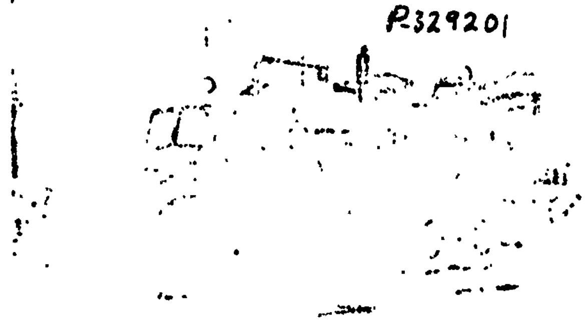

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Machines for Maintenance of Synthetic Surfaces at the Airfield:
1, hosing-washing machine; 2, vacuum cleaning machine.

Repair work on synthetic surfaces are carried out using various mechanized facilities and special equipment. In case of a capital repair of synthetic surfaces of a permanent airfield, flights as a rule are curtailed.

Preparing a Landing Field in the Winter. Winter is accompanied with an abundance of snowfall and creates very real additional difficulties in preparing a landing field. Continual heavy snowfalls create serious difficulties for transportation even in cities where a large amount of equipment and a large number of people are employed to combat the snow. Sometimes it even paralyzes all traffic. It is not difficult to imagine how difficult it is to guarantee the readiness of a landing field of a small airfield under such conditions.

Modern military aircraft as a rule only have wheeled landing gears. Earlier, up to about the 1930's, it was a practice to change landing

gears on airplanes: wheeled landing gears were mounted in the summer and runner-type landing gears were mounted in the winter. It is obvious that in wintertime it is easier to prepare a landing field for airplanes on runners than for airplanes on wheels. However, the use of runner-type gear for military planes is no longer permitted because it is much more complicated to retract them in flight than it is wheels (more space is needed for runners). In addition, the change-over to runners or wheels complicates the combat use of aircraft when the snow cover is stable, i.e., late fall and early spring. Although airplanes on wheels can generally take off from a snow surface of sufficient toughness, it is impossible to take off from an earthen or even more so a synthetic surface with runners (flying aircraft from earthen runways using runners of special design is now being practiced). For this reason, we confine ourselves to the exclusive use of wheel-type landing gear.

It is characteristic for late fall and early spring to have ice form on the synthetic surface of the airfield. This is a real hazard sometimes closing down operations for an extended period. Sheets of ice usually form at an air temperature of 0 to -6°C. As a result of freezing, precipitation of super cooled rain, drizzle or fog, forms a film of ice 0.5-5 mm thick and more on synthetic surfaces. It is very difficult to remove such a film from the surface.

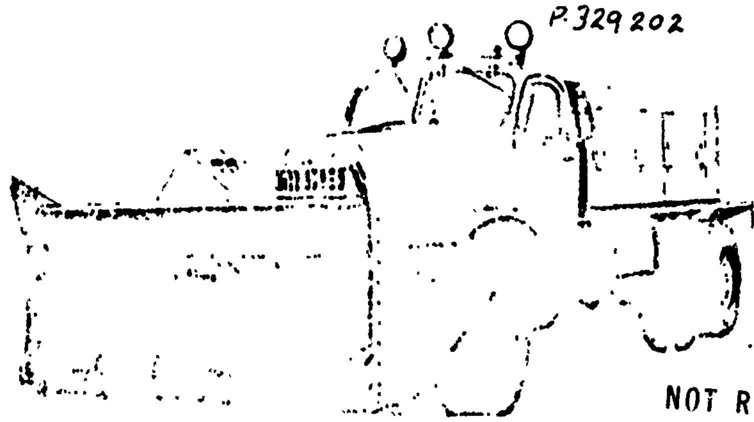
The preparation of airfields in the winter is carried out by two methods: removing snow from the take-off and landing strip (VPP), taxi strips (RD) and parking places (MS) or packing down the snow which covers them. In addition, special snow barriers are used to protect the VPP, RD and MS from snow drifts. The basic method is snow removal. Packing down the snow is used as a secondary method, chiefly at airfields which do not have synthetic surfaces and which are located in areas of constant sub-zero temperatures. This method is also used to retard the thawing of snow on auxiliary VPP during the period of general thawing in the region of the airport.

Snow removal is a reliable but laborious method of preparing an airfield for flight. Snow removal is carried out immediately over a large area using snow-removal equipment of sufficient capacity: systems of snow plows, rotary snow removers, snow-loading trucks, etc.

On first-class synthetic surfaces, snow is completely removed. On the simplified prefabricated sectionalized surfaces and on earthen landing fields, a snow cover of about 5 cm which packs well is usually left.

In order to provide for the rapid readiness of the airfield for flight, snow is removed consistently on certain sectors of the VPP so

that take-off and landing can be carried out on the cleared sectors (runways). Depending on the thickness and density of the snow and also on the presence and direction of the wind, snow removal is accomplished either by snow plowing equipments or simultaneously by snow plows and rotary snow removers. Snow plows collect snow in embankments and push them aside by executing sequential passes along the VPP and RD. Rotary snow removers pick up snow from snow banks and hurl it a considerable distance. The finishing touch in removing snow from synthetic surfaces is provided either by hosing and cleaning machines on which brushes are mounted using special miniature rotary snow removers or by hand.



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Rotary Snow Remover

It must be kept in mind that when snow is systematically removed from the VPP, RD and MS, large masses of it accumulate outside the boundaries of these parts of the landing field. As a result, the airfield is threatened with flooding from melting snow in the spring (during the thaw). For this reason, the snow must be dumped in low places as far as possible from the VPP, RD and MS. In addition, the clean parts of the landing field where snow has been removed must be smoothly (gradually) joined to the uncleared snow. This is necessary for flight safety.

The necessary loading capacity of snow is obtained by packing. A loading capacity up to 7 kg/cm^2 is considered a minimum for modern aircraft. The loading capacity of the snow cover depends upon the density of the snow and its temperature. For example, a loading capacity of 7 kg/cm^2 is obtained when the temperature of the snow is -5°C and density is 0.5-0.55 kg/cm^3. The density of the snow is determined by the ratio of the weight of the sample amount to its volume. A balance-

beam density gage consisting of a graduated metal cylinder and spring balance (or weights) is used. The cylinder is tamped into the snow cover until it hits the ground or ice below. The thickness of the snow cover is red on the scale of the cylinder. Then the cylinder and sample are weighed and the density of the snow is found by dividing the weight of the sample by its volume.

Snow is packed by means of stampers or trailing rollers (wooden, metal, or pneumatic). Stampers and rollers are used joined together in a tandem of three to five and are pulled by tractors. The packing of snow is begun immediately after the first snowfall and is carried out systematically after each successive snowfall or thaw.

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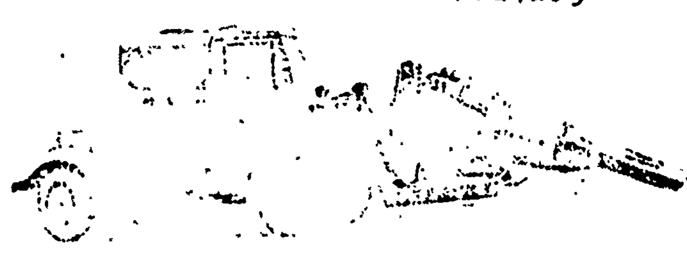

Snow-Melting Machine

The struggle against icing is a very complicated task. Chemical substances and so-called abrasive materials (sand, ashes, etc.) are used to a limited extent on military airfields. As a rule, chemical substances have a corrosive effect on working parts and assemblies of airplanes and damage the surface by chemical processes. Abrasive materials increase the traction of tires of the landing gear, once traction is destroyed by icy film, but it remains on the surface in periods of thaw, and this is not acceptable where modern high-speed, high-altitude aircraft are flown.

The thermal method of combatting ice is thoroughly effective. This consists of the effect of a thermal blast at high temperature and high-speed thrust. Such a blast can be obtained, for example, from a jet aircraft engine mounted on a truck chassis and at a certain angle to the surface of the ground. Similar type systems called snow-melting machines are widely used at the present time at military airfields of all countries where ice formations are frequent. The thermal blast melts the film of ice and blows the water formed outside the boundaries of the synthetic

surface. In so doing, however, it has a destructive effect on the seams of concrete surfaces and on the surface itself. For this reason, ice-melting machines are not used as a rule on asphalt-concrete and other "soft" surfaces.

To Prepare the Aviator for Flight

Flight safety first of all and most of all depends upon the flying personnel. The better the crew members are trained in the technique of pilotage, aircraft control and combat application of airplanes, the more disciplined and faultless a manner in which they carry out the prescribed requirements regulating all phases of flight, the greater the probability that flight will be completed without accident.

The task is not just to prevent flying accidents, but also not to permit the premises for one. The probability of premises for flying accidents occurring increases as an ever increasing number of people of various specialties are engaged in flight support. The example of the effect on flight safety of the delay of a bus carrying flying personnel to a flight was cited above. Similar examples could also be drawn from other activities concerned with preparing the flying personnel for flight. But there is one field of activity where the participation of specialists of airfield-technical support in the preparation of aviators for flight is particularly obvious and where deviation from rules and operating procedures is especially unacceptable. We have in mind the maintaining of health of the flying personnel and, related to this, the providing of food and relaxation. In connection with providing food and relaxation, specialists of airfield-technical support must understand the need to observe the rules and operating procedures in force at any given airfield and any significant deviation from the rules and operating procedures regulating, for example, the food and relaxation of the engineering-technical staff and other specialists of ground support. They must have an idea of the effect of flight conditions on the organism of the aviation. This effect depends, of course, on what type of plane is being flown and under what conditions.

Let us turn our attention to the already-mentioned Manual for Aviation During Wartime, published in Russia in 1916. Page 63 of the Manual states:

"Every flight in general and combat flight in particular has a marked effect on the nervous system of flying personnel. Close-by explosions of enemy shells; engine trouble, which brings to mind the possibility of the engine failing and having to land in enemy territory and facing capture or death - all of these things excite the pilot and observor and wear them down. For this reason and in the absence of pressing

need, pilots and observers will as a rule not be sent to the rear of the enemy more than three or four times per week".

This was written at a time when airplanes flew at speeds of 150-180 kilometers per hour at altitudes up to 3,000 feet (these figures were taken from the same Manual). It can be imagined, if it has not already been experienced personally, how the fliers of modern supersonic airplanes flying at altitudes of 12-15 kilometers and more are "excited and worn down". A special book could be written on this subject[1]. Moreover, the existence of a special branch of medical science - aviation medicine - testified to the importance of these problems.

Here we only touch on the basic factors and how they affect the organism of the aviator flying in a military aircraft. We note at the beginning that along with the factors inherent in any flight, flying in combat is subject to being hit by enemy anti-aircraft shells and missiles, losing cockpit pressure, fire, being wounded and many other things which are practically excluded in flying during peacetime.

During each flight in a combat aircraft the airman experiences the effect of two basic factors; speed and altitude of the aircraft.

The effect of speed of the airplanes is to cause the pilot to increase his tempo of work in piloting the plane, orienting himself in flight, and using the armament and ordnance on board. The faster the speed of flight, the less time the airman has to carry out all of those jobs and the more attention and consequently the more nervous tension is required of him. As the speed of the plane increases, the effect of acceleration experienced by the airman increases with the forces on the aircraft when the velocity changes in magnitude and direction. This affect is characterized by so-called increase in weight (or gravitational effects). Increases in weight caused by a change in direction can be so great that the airman can lose consciousness for a period of time (for example when pulling out of a dive). Increase in weight is a relative magnitude showing how many times a body appears to be heavier when certain forces act upon it.

The force of the effect of the air stream on the airman depends upon the flying speed. So long as the pilot remains in the cockpit of the plane, he does not feel this effect. But when the necessity arises to leave the plane, the effect of the on-rushing air stream may be injurious to him. For example, at an air speed above 500 km/hour, the pressure of the on-rushing stream on the body of the airman trying to evacuate the cockpit exceeds 500 kg, while at a speed of 800 km it is

[1]See K. K. Platonov, "Man in Flight", Voenizdat, 1957.

2,000 kg. At a velocity greater than 500 km/hr, the pilot cannot evacuate the plane on his own power; for this reason, catapult seats which are ejected along with the pilot by means of a special firing mechanism are installed. Moreover, when catapulted from the plane, the pilot experiences for a short duration (0.1 seconds) a 20-fold increase in weight (20 G's) and more. Finally, the speed of the plane is accompanied with an increase of vibrations and noise which have a negative effect on the nervous system of man.

The effect of altitude on the plane's flight is expressed in an abrupt drop in temperature and pressure and also in an insufficiency of oxygen for breathing. It is well known that no matter what airfield the plane takes off from he will meet a temperature of -30°C at an altitude of 7,000 m and -50°C at an altitude of 10,000 m.

On the ground, man experiences an atmospheric pressure exceeding 20 tons (the body surface of man is approximately 20,000 cm^2). Man does not feel this pressure because it is equally distributed over his whole body and is equalized by an internal pressure within his own body of the same magnitude. Atmospheric pressure decreases with an increase in altitude. At an altitude of 5,500 m it is about one-half and at an altitude of 10,000 m about one-fourth of the pressure at sea level. Therefore, an increase in altitude, especially rapid increase, causes painful sensations in the stomach, ears and other organs of the body. A rapid descent of the aircraft also has an unpleasant effect on the body of the airman (sometimes this is noted even by passengers, for example, on the Tu-104).

The insufficiency of oxygen with an increase in altitude leads to "oxygen starvation" of the organism which can cause a loss of consciousness and even death. At an altitude of 8,000 m, man perishes without a special supply of oxygen. Flying can be accomplished with safety without oxygen supply up to an altitude of 4,000 m. If an airman jumps with a parachute from an altitude above 12,000 m with a supply of oxygen, he will lose consciousness and perish before he reaches the safety zone (6,500-7,000 m) even if he descends in a free-fall without opening his parachute.

These are the chief difficulties which the airman may meet when flying at normal speed and altitude, and which he must be prepared to combat. However, the airman flying on a combat mission must be ready first of all to accomplish his mission. Therefore he must be conscious both on the ground and in the air of the conditions permitting him to prepare for and carry out his mission in spite of the difficulties encountered.

Let us return once again to the 1916 Manual, which states on Page 177:

"Aerial combat is a fight to the death. Every pilot must go into combat with the firm conviction that either he or the enemy will perish."

If his airplane was shot down, the pilot of those days could count on being saved only by a miracle. The modern-day pilot who carries out his combat mission under incomparably more difficult and complex conditions has a large number of special devices and equipments which contribute towards saving his life if his plane should be damaged or shot down by the enemy. The pilot has at his disposal a number of life-saving equipments including the catapult ejection seat; parachute with oxygen equipment and a supply of oxygen; compensatory clothing designed to reduce the injurious effect of the excess oxygen pressure when flying in an unpressurized cockpit or when ejected at an altitude above 12,000 m; protective helmet and other devices including individual diving suit. To save the lives of crew members who might jump from the plane over the ocean (seaplanes, airplanes or helicopters of the Naval Air Arm, etc.) life vests and inflatable life-boats are also provided.

Specialists of airfield-technical support also must take part in preparing all of these life-saving devices and in checking and storing each of the individual items.

Food for the flying personnel as well as schedules for work and relaxation has become a matter of concern of aviation medicine. This is not to say, however, that great attention was not paid to these problems earlier. Let us cite just one example.

Mikhail Vasil'evich Vodop'yanov, the famous pilot and one of the first Heroes of the Soviet Union and now quite well known as a writer, published a book in 1967 entitled "Friends in the Sky" (Izdat "Sovetskaya Rossiya"). Reminiscing about the early years of Soviet aviation, he cites the following fact. During the period of the Civil War a division of air ships was created from the surviving "Ilya Muromets" Russian heavy bombers, and this division took part in many combat operations. It is well known that V. I. Lenin followed the utilization of aviation in the Civil War very closely. And in the difficult time of starvation and collapse, Vladimir Il'ich signed a decree of the Soviet of Labor and Defense which stated: "Colleagues of the Division of 'Il'ya Muromets' air ships who are actually accomplishing take-off and flying operations must be satisfied with the standards and procedures announced in Order Number 1,765 of the RVSR (Republic Revolutionary Military Council), and the other colleagues of the same division at the front must be satisfied with front rations and those of the rear with rear rations."

The peculiarity of food and the attention he gave it were occasioned by two circumstances. First of all, proper and regular food is the foundation of the health of any person and it is necessary for fliers to be in good health. Secondly, in the air the airman experiences the effect of changes in pressure, insufficiency of oxygen in the blood, and increases in weight (G's). Therefore the feeding of airmen must be regular without unexceptible interruptions in excess of standards; the food must not only be sufficient in terms of calories but also must contain concentrations of protein, fats, carbohydrates, minerals, water and vitamins in the proper proportions. Airmen should have the opportunity to choose a dish or order it in advance, taking the immediate operation into consideration since there are different requirements for food rations when engaged in flying or engaged in ground preparations. The type of flights also has an effect on the food ration and its scheduling: rations for day, night, high-altitude, long-range flights, etc. Moreover, in long-range flights, aircraft crews must have on-board food which also has specific characteristics both as to ration and method of preparation. However, the ration and eating schedule is in general not at all the most complex thing for ground support specialists. It is difficult to provide food for flying personnel according to required ration and schedule, for example, in the winter when fresh vegetables and consequently vitamins are a problem. Additional difficulties are encountered in the polar regions and in Central Asia. But the most difficult thing is to provide appropriate food under combat conditions when everything is in flux, when units are based on forward (field airfields) not having stationary kitchens and dining rooms, where there are difficulties in providing and storing food products. But even under these conditions of combat operations, the airmen more than ever need good, regular meals to help maintain their health and to quickly restore physical and moral strength for new battles.

Under combat conditions, food is prepared in portable kitchens and kitchen-dining rooms. To prepare good, tasty, high-calorie food with variety under such conditions requires great skill, know-how, love for the job and a sense of duty. Good food service specialists are necessary to measure up to this task.

Another job in preparing flying personnel for flight is the provision of rest and relaxation. Fatigue is the regular physical process whereby the work capability of the organism (individual organ) diminishes with time and occurs as a result of activity. Fatigue is a normal reaction to any activity. In circumstances where appropriate relaxation takes place after fatigue, it is not a factor having a negative effect on the organism. In the reverse case there may be over-fatigue, the results of which may be quite serious. The fatigue may be mental or

physical depending on the type of work to be carried out, and in order to overcome it, appropriate relaxation is required. One of the most valuable forms of relaxation is sleep. A second form of relaxation is a change of activity, i.e., active relaxation. When actually flying, the airman grows tired both physically and mentally, and for that reason relaxation of all forms is necessary to renew his work capability.

It is not very difficult to provide for the relaxation of flying personnel on off hours in peacetime at a permanent airfield where the airmen live in well built apartments with their families and where there are cultural and educational institutions and sports activities. But along with relaxation on non-duty hours, it is necessary to create special conditions for airmen to relax at the airfield during breaks during flights, directly before flights and even after flights. Here, too, specialists of airfield-technical support play a role. There must be rooms at the airfield in which airmen can rest during the breaks between flights independent of climatic conditions, weather and time of day. These rooms should be furnished in an appropriate manner. A great deal of attention must be paid to rooms in which crews of duty units are located. Many airfields have health centers where airmen can easily relax and renew their strength after strenuous flights or before flights.

Getting the aircraft ready requires that specialists of airfield-technical support strictly observe certain rules and orders and that they know how to accomplish certain jobs or operations using complex technical facilities. In providing meals and relaxation for the flying personnel, it is necessary not only to observe established standards, rules and procedures, but also to exhibit intelligent initiative. Stereotype approaches, formalism and bureaucracy are not acceptable in this matters. Here as no where else there is a necessity for love of work, persistence, inventiveness, and sometimes even imagination. Of course, all of that should be tempered with a feeling of moderation, a correct understanding of beauty and style, and the ability to anticipate and understand peoples' desires, their wants and tastes, along with the ability to inculcate good taste in others.

It is especially difficult to provide meals and relaxation in an appropriate manner when airplanes are based on forward (field) airfields in periods of combat operations. However, as the experience from the Great Fatherland War shows, even under these conditions specialists of airfield-technical support can do a great deal if they are prepared for work under such conditions and if they firmly appreciate what airmen are - this is the most valuable and important thing in aviation.

The whole discussion of meals and relaxation for flying personnel

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was begun here in connection with the problem of flight safety. If the airman has been fed on time and has relaxed well, then he will feel well in the air, and that is a plus for flight safety. We merely wanted to point out that meals and relaxation play an important role in preparing the airman well for flight and that many specialists of airfield-technical support take a direct part in it.

How Airport-Technical Support Is Managed

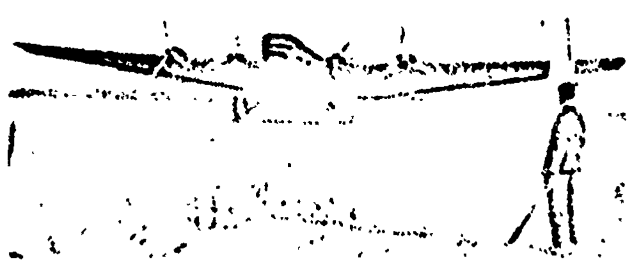
Flights are carried out at the airfield. No sooner does the silvery airplane roar down the runway and take off into the air than another airplane lands on the very same runway, slowing its landing gear by means of drogue shoots. Using the same taxi strips, airplanes taxi to parking places or to positions preparatory for subsequent take off, while tractors tow airplanes already prepared for flight along other taxi strips. The roar of the engines drowns out all other noises at the airfield, and it seems as if the various ground vehicles scurrying along the airfield in different directions are moving noiselessly.

The passengers of Aeroflot also observe something similar as they find themselves in the glassed-in or open terrace of the passenger terminal. However, the surroundings there are quieter and they are enlivened with large groups of passengers arriving and departing. At a military airfield, the surroundings are more severe but also more dynamic, rapidly changing, and everyone understands that the tense and hurried work in such circumstances must be organized and run some how and by some one. There are two basic areas of activities involving people and vehicles at the airfield during flight operations. First, there are the take off, the execution of specified flight missions within the designated zone and along established routes, and the landing at the airfield. Secondly there is the preparation of aircraft and crews for flight at the airfield.

Using a more careful approach to the problem, we are completely justified in subdividing the second of these areas into two more: the work of the engineering-aviation service in preparing the airplane for flight and the work of specialists of airfield-technical support in preparing airplanes and crews for flight. Thus, in speaking about flying operations at an airfield, we understand strictly the flights of aircrews in airplanes and the engineering-aviation and airfield-technical support provided. Accordingly, in speaking of flights control at the airport, we must speak of controlling take-off, activities of the crews in the air and landing of the airplane, as well as of controlling engineering-aviation and airfield-technical support.

We have already partially considered controlling take-off, activities

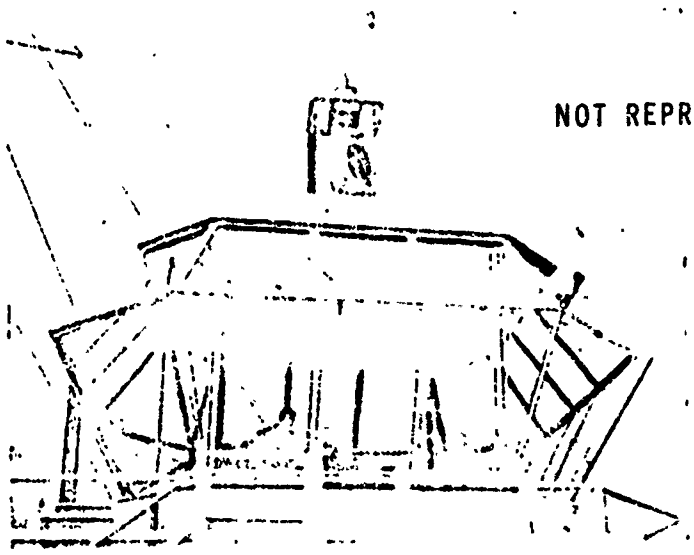
of the crews in the air and landing when we discussed the equipment of the landing field and the servicing and equipment zone of the airfield. Let us remember that we talked about stationary and mobile control points, radio communications and radio technical facilities and also about the light-signaling equipment of the landing field. All of these facilities are at the disposal of the flight controller at the airport who also controls take-off, landing and the activities of the aircrews in the air with the help of technical facilities mentioned and the personnel operating them. We can add that the flight controller provides general supervision over the flying activity at the airfield acting through appropriate specialists - representatives of the engineering-aviation service and the airfield-technical support. He coordinates and directs the work of providing services according to his flight plan and the circumstances which have developed during the flying operations. The flight controller is like a captain on a ship or a commander on a multi-place airplane - he is the omnipotent and responsible person to whom everyone taking part in flight or flight support is absolutely subordinate. It cannot be otherwise in such a complex, dynamic system at times fraught with unforeseen events, which accompanies flying activities.



This Is How Take-Off and Landing was Controlled

But let us turn to airfield-technical support. Is it necessary to exert special control of this support, and if so, how can this be done? Only one answer can be given to the first question: yes, it is now necessary to control airfield-technical support, and this is the reason why. Many specialists using a large number and variety of technical facilities to accomplish support jobs take part in airfield-technical support to flying. We have already mentioned refueling; charging with compressed gases, special liquids and liquid oxygen; supplying airplanes with a variety of means of destruction; starting the aircraft's engines; and towing. If only one item were taken from each of the technical

facilities involved in carrying out the jobs specified for flight support this would come to about ten different items. In flying several planes or, and this cannot be excluded, several score of airplanes at the airfield, a number of items of each of the technical facilities is used. In addition, so-called special duty technical facilities are designated independent of the number of aircraft flights involved. What is their purpose?



Flight Controller at the Command Dispatching Point

During periods of flying, cases of accidents on landing on the airfield cannot be excluded, and all the more so under combat conditions. Such airplanes interrupt the take-off and landing of other airplanes and therefore must be removed from the landing field as quickly as possible. This is not a simple task since the dimensions and weight of modern airplanes are large. Special hoisting and transporting facilities are needed to remove such airplanes, and during the period of flying these facilities are located on the airfield in constant readiness for work.

In the case of an accident on landing and also in a number of other cases (e.g., in refueling) a fire can start on the plane or on the ground vehicle. The large quantity of fuel and ammunition on military aircraft and also other highly inflammable and hence dangerous materials forces the adoption of quick-acting, effective measures to extinguish fire and sometimes also to prevent it. Part of the personnel (specialists) and technical fire-fighting facilities of the duty facilities of airfield-technical support are set aside for this purpose.

Medical personnel and ambulances make up part of the duty personnel and facilities for rendering assistance to members of flying crews in the case of an accident on landing. In wartime, medical assistance may even be needed in normal landing if members of the crew have been wounded in the process of carrying out their combat mission.

Specialists of airfield-technical support take part in marking off (laying out) the landing field and darting the landing field during flight operations. They operate emergency braking equipment and carry out other work which becomes necessary under the concrete conditions of flying certain type aircraft at a given airfield. Required special facilities and transport facilities are used for this.

Thus, many specialists and a large number of technical facilities are constantly used at the airfield in airfield-technical support to accomplish varied support tasks. They rush out to meet the airplanes, they make runs to the supply depots and back, they transport personnel or, finally, they go back to their parking station where they wait for calls when needed. Airfield-technical support facilities of the airfield work over a large area where individual buildings are located several kilometers from one another, from the aircraft parking places, or from the landing field.

Finally, the most important point. The activities of the personnel and facilities of airfield-technical support must be carefully coordinated with the activities of specialists of the engineering-aviation service who are getting airplanes ready for flight. In addition, it becomes necessary to adjust rapidly the earlier planned activities to accommodate the situation at hand, the plans of the aviation commander, or any other unforeseen circumstances. All of this makes necessary a centralized and continuous management of the airfield-technical support personnel and facilities.

Turning to the question of how airfield-technical support should be managed, the following basic measures in the organization of management are offered. Requests for flight support are made by the aviation commander usually the day before (or night before) flying. All of the resources set aside for airfield-technical support are available to the duty officer-specialist. The duty officer has constant, direct contact with the specialist in charge of the engineering-aviation service concerning the technical facilities being used for preparing aircraft. On report (request) of the responsible representative of the engineering-aviation service, the duty officer dispatches the required facilities to the designated aircraft or to designated places. He constantly checks on the availability and operating condition of the facilities furnished to the commander and sees that they are reinforced or replaced if need be.

Sometimes, chiefly in support of training flights, airfield-technical support facilities are attached to certain airplanes taking part in flights, and their chiefs furnish technical facilities themselves at established intervals after the landing of the airplanes to which these facilities are attached.

In recent years, mobile control points of the engineering-aviation service have been expanded. This has been caused by a number of circumstances, chiefly by the complexity of checking out and preparing modern aircraft for flight. Since a great many airplanes are flying and flight density is very great, an effective estimate of the readiness of airplanes and a careful distribution of the large number of specialists and technical facilities to them are needed. All this is done with the help of equipment available at the individual control points.

The duty specialists of airfield-technical support who is at or near that point and who is close to the technical facilities designated for his use, manages them in accordance with the demands of the senior specialists of the engineering-technical service. Miniaturized radio sets are being used more and more for managing support. They are located with the technical facilities, at materiel supply points and at motor pools, permitting the duty officer, who has a similar radio set, to issue orders directly to the facility chiefs and supply workers and motor pool officers. Flares, bull horns and other means are also used to dispatch technical facilities to the airplanes.

Constant and accurate management of airfield-technical support is one of the most important conditions for flight safety. Management is not merely issuing appropriate orders to the people who carry them out. In the process of management, the duty officer for airfield-technical support must exert control over the activities of support personnel and facilities, access the actual conditions which obtain on various flights, and makes skillful use of the personnel and facilities at his disposal.

We cite one example confirming the necessity for continuous control. It is well known that people and technical facilities move around the airfield in strict accordance with certain rules, especially in getting an airplane ready for flight. These rules are set at each airfield taking local conditions into consideration and should be familiar to the entire personnel. Failure to observe traffic rules on the airfield is a premise for an accident, and sometimes even an airplane accident. We already stated that scores of various-purpose technical facilities presently take part in the preparation of airplanes. It is not hard to imagine the threat to flight safety which arises in the case of uncontrolled movement of all of these vehicles in the support process.

It must be stated that the complex and responsible tasks in the management of airfield-technical support can only be satisfactorily accomplished by highly qualified specialists who have the knowledge and experience of commanders.

In supporting flying operations, the specialists of airfield-technical support takes part in resolving the most important problems of the aviation rear - those of maintaining a high combat readiness of aviation.

5 —

Combat Readiness - The Most Important Task

Our military aviation, along with all the Armed Forces, has already stood on guard over the achievements of the Great October for a half century. The birth and development of Soviet aviation, its history and victories are inseparably bound with the activity of the Communist Party, its Central Committee, and the Soviet Government, and Vladimir Il'ich Lenin personally, on 28 October (10 November) 1917, ordered the formation of the first socialist aviation squadron.

During the years of the Civil War and foreign intervention, red combat missions flown in old, wornout airplanes fearlessly destroyed the enemies of the young Soviet Republic. Two hundred thirty five fliers and observers received the highest government combat decoration of that time - the Order of the Red Banner - for deeds and heroism shown in these battles, and 16 of them were decorated twice.

The most severe trial for our whole nation was the Great Fatherland War (World War II). Persistence, courage and self-sacrafice were displayed in full measure in this war by the entire personnel of military aviation in the struggle with the enemies of our country. From the very beginning of the war, our pilots fearlessly and out-numbered, engaged in aerial combat with the enemy, and during the war Soviet pilots flew a total of about four million combat missions. More than 200,000 aviators received government decorations for military work, 2,420 aviators earned the title of Hero of the Soviet Union, 65 won this title twice, and two - A. I. Pokryshkin and I. N. Kozhedub - received it three times.

From the time the first socialist aviation squadron was formed in 1917, along with pilots, navigators and radio gunners, ground-support specialists also made a significant contribution to the victory over the enemies of the homeland. Among the aviation personnel who earned government decorations during the Great Fatherland War, there were thousands of engineers, technicians, mechanics and workers of the aviation rear. The battles of the greatest war in man's history were victoriously concluded by our Soviet people, the thunder of battle subsided, and our military aviation once again stands guard over the peaceful sky of our homeland.

In the post-war years, the Communist Party and the Soviet Government have been very attentive to the development of military aviation. Taking advantage of the remarkable achievements of Soviet science and technology, aviation has acquired a new image: it is characterized by jet aircraft, supersonic speeds, and missile launchers. Its combat possibilities have immeasurably widened.

The Air Force consisting of front (tactical), long-range, transport, and special-purpose aircraft is a particular branch of the Armed Forces. The National Air Defense Force (PVO) has fighter aircraft, and the Navy (VMF) has an air arm equipped with long-range missile carriers, air-defense aircraft and other airplanes designed for joint action with the fleet.

At the present time, military aviation has first-class aviation equipment, a variety of armament and ground support facilities. This permits it to work together with the other branches of the Armed Forces and branches of service in the successful accomplishment of tasks in the defense of the homeland from aggressive enemy actions. However, the presence of first-class equipment and armament by itself does not guarantee the success of combat operations. It is necessary for this equipment and armament to be constantly ready for combat operations and to be in the hands of skillful and self-sacraficing service personnel.

It is well known that under modern conditions, where armies are equipped with nuclear weapons and other powerful means of mass destruction, a surprise attack of the enemy can result in very serious consequences. The imperialists make no secret of their plans for surprise attack which, in their opinion, assists them in achieving the stated goals. An obvious example of this is the Israeli aggression against the Arab countries which began with a surprise aerial attack on airfields.

The Secretary-General of the Central Committee of the Communist Party of the Soviet Union, L. I. Brezhnev, noted in his address before graduates of the military academies in June of 1967 at the Kremlin:

"The Soviet Armed Forces as a whole, each division and each fighting unit must stay in such a state of preparedness that there is not the slightest possibility of the aggressor taking us by surprise."

If the imperialists unleash a war against countries of socialist solidarity, they may begin combat operations with a surprise attack using nuclear or conventional weapons. A war begun with conventional weapons can turn into a nuclear war. Consequently, our Armed Forces, including military aviation, must always be ready to carry out combat operations using nuclear missiles and other forms of mass-destructive weapons.

In modern warfare, not one operation, no matter how significant, can be imagined without the participation of aviation. The Air Force will accomplish various combat tasks: destroy and demolish combat objectives in the rear of the enemy, destroy the rear (in coordination with ground forces and fleet) in ground and sea theaters of military operations,

carry out air reconnaissance, effect assault landing of large units, and support troop maneuver. Jointly with other air defense facilities, the fighter aviation of the Air Force (VVS) and Air Defense (PVO) will provide cover against enemy air strikes for ground forces, industrial and administrative centers of the country, the population, and various targets of the country and of the Army. The Fleet Air Arm (VMF) will take action against surface and underwater craft of the enemy and support combat operations of our own ships and Marine troops. Consequently, military aviation and its individual branches and services must be constantly prepared to carry out eminent military operations.

Thus, by readiness of aviation we must understand the capability of carrying out its natural tasks under any combat situation, to act in coordination with other branches of the Armed Forces to achieve a rapid and decisive defeat of the aggressor. Such an understanding of combat readiness is justified both for aviation as a whole and for each aviation division and unit individually. It must be considered that each unit has its own combat tasks which are peculiar to it and to the given branch of aviation. For this reason, concrete requirements are established for the combat readiness of each aviation unit.

If the requirements for combat readiness levied on any particular aviation unit are compared with the actual condition of combat readiness of that unit, it is possible to get an idea of the level or degree of its combat readiness. The more the actual combat readiness corresponds to the requirements levied by a certain command, the higher its state of combat readiness, the higher and more manifest is its capability for carrying out combat operations and for resolving concrete combat problems under even the most complex circumstances.

How is the level of combat readiness confined? The answer to this question is not simple since a large number of the most various elements of life and troop activity can be cited which affect the combat readiness of troops in general and of each fighting unit, including aviation units, in particular. It must be emphasized in this connection that each element has an effect; everything that is done by the personnel in the troop elements and in each unit. Such an effect can be larger or smaller. It is possible to cite some basic elements which exert a greater influence and are therefore the basic or chief elements. These elements are: political and moral condition and discipline of the troops; level of training of personnel on how to act under complex situations; field training, level of special preparation, condition of arms and equipment; availability and operating condition of materiel supplies necessary for combat operations; organizational capabilities of the command staff and its special preparation; and orientation training of personnel on how to act in an alert.

In other words, continuous combat readiness presupposes ordering the routine of daily life and activity of the troops and the level of combat and political readiness of the personnel in a way which will promote at any given moment a rapid and organized execution of the assigned combat mission underthe most complex circumstances. All of this is justified in relation to the level of combat readiness of all troops, including aviation.

In addition, there are some special elements in aviation defining the level of combat readiness of the aviation units. The presence of such elements is explained by the dependence of aviation on the ground materiel base which was discussed in detail in preceding sections of this book. The most important of these elements which are peculiar to aviation are: condition of airfields, availability and operating condition of ground-support facilities and personnel, capability of the ground facilities and personnel to support the rapid maneuver of aviation units during the course of combat operations of troops.

In this way, the level of combat readiness of the aviation unit is determined by the condition of a large number of elements, among which are elements which apply to all troops and elements which are peculiar to aviation. Since this book is devoted to problems of airfield-technical support, it is proper to pose the question here as to what degree and what manner does the condition of aviation-technical support affect the combat readiness of the aviation unit. Turning once again to the subject of the above-mentioned elements, we will find without difficulty that among them are some elements, the condition of which directly depends first of all on the organization and quality of airfield-technical support. In fact, in some instances this dependence is so vital that it practically determines the condition of the combat readiness of the aviation unit.

Let us take, for example, such an element as the condition of the airfield. If the airfield is not suitable for use, then even the aviation unit which has excellent flying personnel, who are trained and effective in flying combat aircraft, will be unsuitable for carrying out a combat mission owing to the impossibility of taking off from the airfield. It is clear that in this case the condition of the airfield is defined by the capability of the aviation unit to carry out a combat mission, and consequently by the level of its combat readiness.

The quality of airfield-technical support has no less a vital effect on the condition of such an element as the readiness of the combat equipment of the aviation unit. If the airfield-technical support for the preparation of airplanes for operations is slow and disorganized during an alert, then the aviation unit will not be able to carry out the combat

assignment within the time established by the commander, and, consequently, the level of its combat readiness will be low and will not satisfy the requirements levied.

The absence of necessary materiel and technical facilities at the airfield can also interrupt or delay the preparation of airplanes for combat flights, and an inadequate preparedness for rapid re-deployment on the part of the personnel and facilities of airfield-technical support can delay the re-deployment of the aviation unit at another airfield, as a result of which the unit can be hit by the enemy and sustain losses which reduces its capabilities to carry out the assigned combat missions.

So far we have discussed those elements which determine the combat readiness of an aviation unit, the condition of which depends directly on airfield-technical support. However, the organization and condition of airfield-technical support exerts more or less real effect on many other elements of the combat readiness of the aviation unit. In a number of incidences, this effect is not immediately evident.

For example, the level of preparedness of airmen of an aviation unit or the operating condition of the aircraft are most important elements which determine the combat readiness of the unit. Does the condition of these elements depend on airfield-technical support? Certainly, even though the relationship is not visible, as in the case of the condition of the airplane mentioned above. So the necessary level of preparedness of the airmen for combat operations is achieved during the course of their combat training, and this training is a composite of the daily training flights, the quality of which depends on airfield-technical support. Aviation-technical units provide for the repair of airplanes of the aviation units, and consequently the timeliness and quality of the repair work and hence the combat readiness of aviation equipment depends on the timeliness and completeness of this support.

Examples of the effect of airfield-technical support on the condition of the combat readiness of an aviation unit may also lead further, since in practice this effect is felt on the majority of elements of combat readiness. However, if we limit ourselves to what has been said, it is sufficient in our view to point out, first of all, the importance and essence of such an effect, and secondly, the need for maintaining at a high level the combat preparedness of the personnel and facilities of airfield-technical support itself. The last conclusion needs some explanation.

In order to maintain the landing field of the airfield in a constant state of readiness, to provide rapid and organized support for preparing

airplanes for flight during combat alerts and to accomplish timely completion of all tasks connected with the airfield-technical support for combat readiness of the aviation unit. It is necessary not only to have available support facilities in good operating conditions, but also to get them ready to carry out required tasks. In turn, getting support facilities operationally ready in a timely manner and carrying out the support work itself, depend on the speed and degree of organization of the activities during an alert both of the personnel and the specialists who work on these facilities.

The rapid assembly of the personnel during an alert to assure the possibility of rapid and organized follow-on actions is most important of all. Therefore, all means must be adopted to shorten the time needed to gather the personnel together. This will have an immediately effect on combat preparedness and will increase it. Success in solving this problem depends on the timely warning of the personnel of a combat alert, and the speed and degree of organization of activities after receiving the signal - activities which end in the arrival of the personnel at the appointed place completely prepared to carry out their tasks.

The firm knowledge of each specialist of his concrete responsibilities during an alert and his ability to carry out these responsibilities quickly and correctly under any kind of circumstances, has an enormous significance. This is achieved by systematic training in the actions to be carried out during an alert and in the daily clarification of the tasks of each service man. In this regard, the activities during the period of training and training alerts should be identical to those of a combat alert, otherwise it is just "playing with soldiers", which inflicts irrepairable damage to military preparedness. The personnel should be trained to bring their arms, equipment, transport, and means of defense into a rapid state of readiness. Otherwise, the rapid mustering of the personnel will not give the desired results since all the other subsequent activities are, as a rule, connected with the use of these facilities.

The accuracy and speed of the follow-on activities of the specialists of airfield-technical support depend on the level of their knowledge and practical experience in the execution of operations supporting the preparation of aircraft for combat flight and also for providing rapid and organized relocation to new regions and to new airfields in support of subsequent combat operations of the aviation unit and other tasks required under conditions of the real situation. In this regard, the level of discipline of the personnel, their preparedness for action in complex situations, their field training and psychological preparedness all have a great significance. The ability to maintain calm, self-control,

persistence and courage under difficult conditions are qualities necessary for the successful execution of tasks of airfield-technical support in the combat preparation of the aviation unit under conditions of possible enemy coersion using weapons of mass destruction.

In peacetime, a high combat readiness is achieved by stubborn and tedious labor on the part of the entire personnel. Training and education of the personnel in the interests of increasing combat readiness is possible on the basis of a steady realization of the working principle - teach the troops what is necessary in war. Training and practical work of specialists of airfield-technical support should be directed toward further shortening the time required for combat readiness and an undeviating execution of the requirements of manuals and instructions, orders and requirements regulating the procedures for maintaining all elements of combat preparedness in the proper conditions.

It is necessary to emphasize that all the work of airfield-technical support in peacetime, no matter how varied it may be, should be directed first of all at accomplishing the chief task - assisting in the combat readiness of aviation. This is required by the security interests of our homeland and this is the duty and responsibility of the entire personnel. The guarantee for the successful accomplishment of this chief task is the conscienciousness and level of discipline of the service man; continuous improvement of knowledge, skill and experience in the course of combat preparation; high order of field training and continuous combat preparation of the support personnel and facilities.

The imperialists of the USA who have adopted the role of world policemen are holding the world on the edge of a nuclear catastrophe. It suffices to note the flights of American strategic bombers which hydrogen bombs on board. In the Federal Republic of Germany the revanchists are raising their heads and becoming more insolent as they vigorously work to acquire the right to nuclear weapons. All is not quiet in the world, and only the might and high military readiness of our Armed Forces and the armies of the countries of socialist solidarity are capable of guaranteeing peace and curbing aggressors. Officers, non-commissioned officers and enlisted men working in the field of airfield-technical support must properly contribute their unheralded but important and responsible share in the matter of combat readiness of the Armed Forces and the military aviation branches of it.

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13. ABSTRACT

The book deals primarily with military airfields, describing types, design and construction, operation and management. It discusses the functions an airfield must perform to support aviation and how an airfield is organized to carry out these functions, e.g., flight service, maintenance,armament, refueling, traffic control, etc.

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Landing procedure						
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Flight service						
Technical support						
Engineering Support						
Airfield Construction						
Runway surfaces						
Seaports						
Aircraft carriers						
Helicopter carriers						